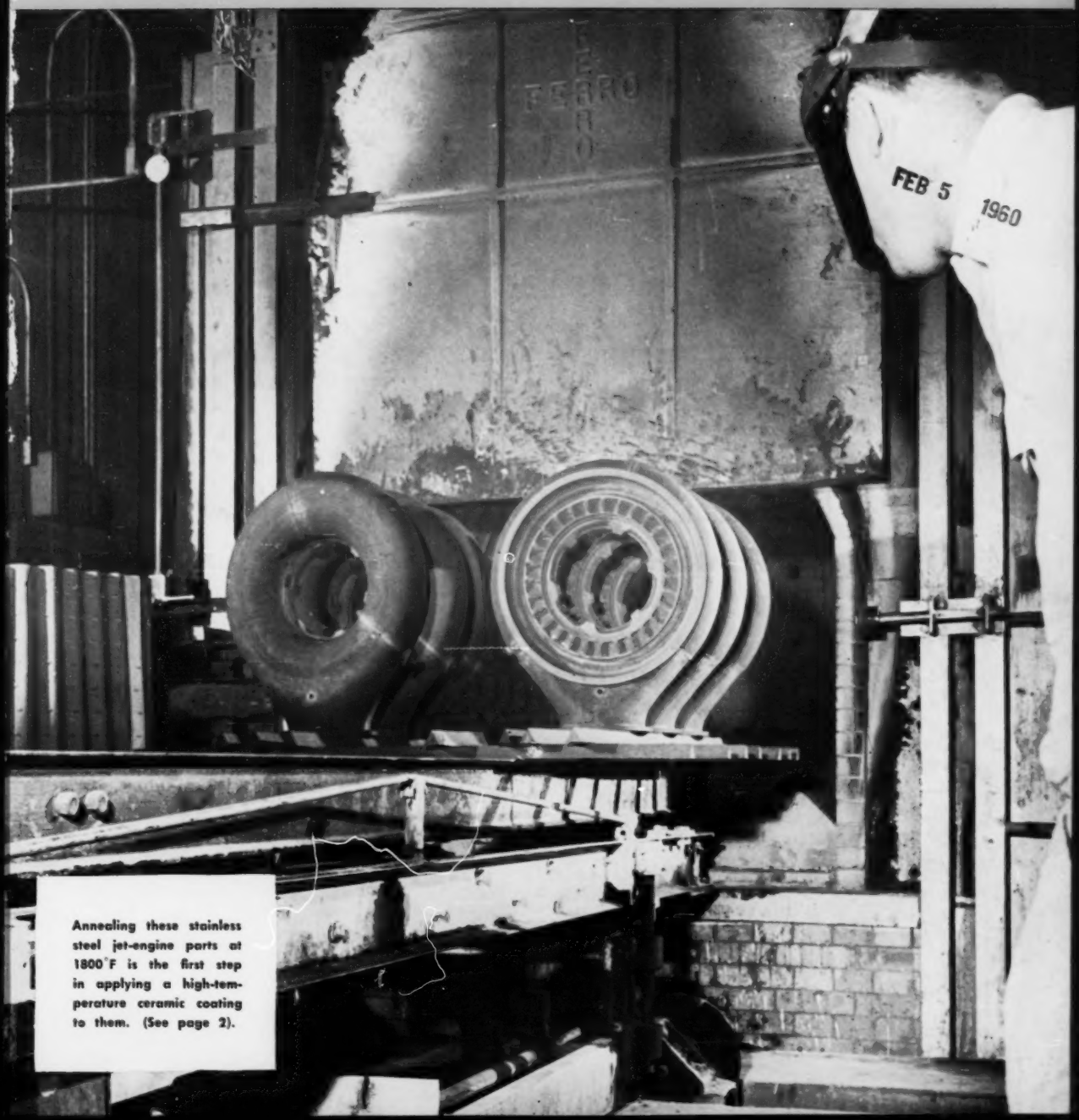
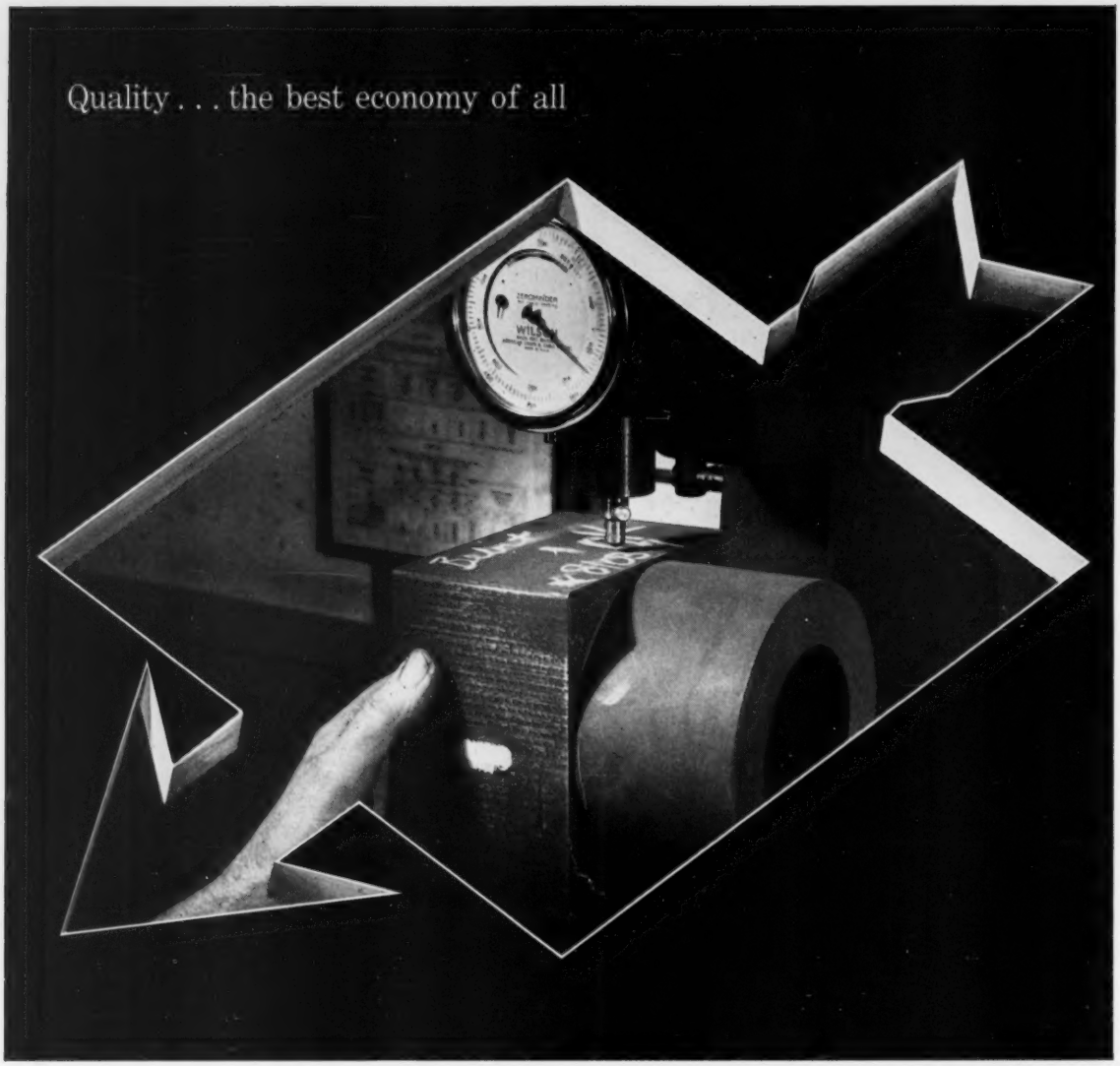
JULY
AUGUST 1959

# Metal Treating

THE *ONLY* MAGAZINE DEVOTED EXCLUSIVELY TO THE HEAT TREATING INDUSTRY




Annealing these stainless steel jet-engine parts at 1800°F is the first step in applying a high-temperature ceramic coating to them. (See page 2).

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Vol. X
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No. 4



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# NEW DEVELOPMENTS IN HIGH TEMPERATURE CERAMIC COATINGS

By **FREDERICK D. SHAW,** Vice Pres. & Gen. Manager
The Bettinger Corporation
Milford, Mass.

GREAT STRIDES in the development of mankind's mastery over heat and metals have been made in a comparatively short time. The steel industry was not developed until the 19th century after the ceramist had provided the necessary brick and crucibles for the containment of molten metal.

### Metallurgical Developments

Since that time, the science of metallurgy has developed tremendously in a never-ending search for better high-temperature material. Today we are not concerned with materials for a steam turbine operating at 1200°F, but with materials for a gas turbine operating at 2000°F or with a rocket nozzle operating at 5500°F.

At one time the 1200°F material was a very serious problem. Now we are working in the range of 2000°F; 3000°F is on the way and 5000° is not beyond the realm of possibility. This is progress, and the demands will never diminish.

If we consider the 92 natural elements, not more than 20 have melting points above 3000°F and the limit of alloy usefulness is 2200°F. This is one property we can do nothing about.

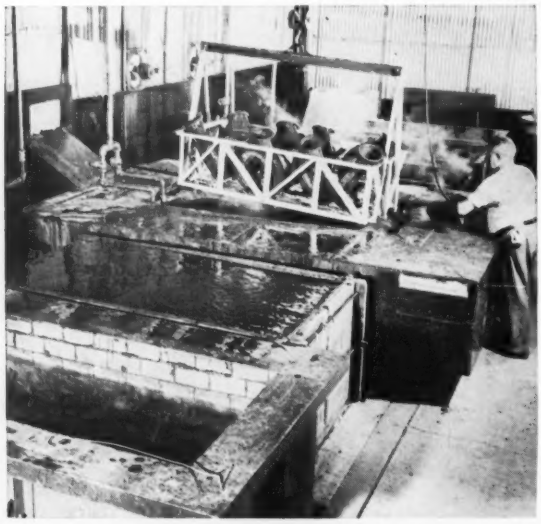

*Fig. 1—After the nozzle boxes have been annealed at 1800°F ± 25°F for 10-15 minutes to relieve stresses and bring out scale on the surface to improve effect of pickling or etching, they are next given an acid treatment as shown here. It removes scale and etches surfaces completely clean. Box around acid tank is part of exhaust system, which is most important because solution of nitric and hydrofluoric acids is maintained at 200°F.*

Metallurgists have done a great job in material development. Starting with iron base materials they have created new alloys, stainless steels and now the chromium-based materials. They know the effects of minor additions and of impurities on physical properties; they understand what is happening in creep, what goes on in heat treatment, and what the properties of the materials are.

The great strides made in metallurgy are now being duplicated in the science of ceramics. Comparable advances are being made up the temperature scale.

The metallurgist has been fortunate in the materials he has to work with. He can melt, cast, heat treat and have a homogeneous mixture with a wonderful metallic type of bonding which permits flow, ductility and good impact properties. Unfortunately, it is some of the properties of the metallic bond which are now limiting the operating temperature of the alloys.

### Development of Ceramic Coatings

These limitations have resulted in greater interest in ceramics, first in military uses such as jet engines, rockets, earth satellites, launching pads, etc. And now increasing attention is being paid to the host of peacetime needs which have developed in the past few years.

The Bettinger Corporation, for example, now uses more than 20 different coatings on a production line basis, with more than 400 specific laboratory applications. These are being swiftly converted to production basis as the need and demand arises.

At this moment, coatings are grouped into three basic types:

1. For use on low carbon or low alloy steels.
2. For use on stainless steels of either American Iron and Steel 300 or 400 series.
3. For premium temperature alloys.

Coatings for the electronics industry and for resistance to corrosive liquids at elevated temperatures might represent two additional types; progress in these fields, particularly the former, has been remarkable in the past year or so.

### Types of Coatings

Coatings for low carbon or alloy steel are basically

*Fig. 2—Spraying covers outside surfaces of nozzle box. Expert operators are required for this work because cast thickness must be held at from 0.001 to 0.0015 in.; less than this doesn't give 100% protection, more tends to allow spalling during thermal-shock tests.*

a cobalt base groundcoat. They are usually made by incorporating one hard groundcoat and one low-firing groundcoat with the addition of 25 pounds of calcium alumina to 100 of frit. This proportion varies somewhat. The purpose of the low-firing groundcoat is to seal off oxygen at low temperatures to prevent oxidation of the metals as the temperature is raised. After the coating has fairly well matured, the alumina takes over to form a refractory, heat-resisting coating.

Applications using stainless steel in the AISI 300 and 400 series can be made with many modifications. The Bettinger Corporation has developed hundreds of formula variations to obtain special characteristics. Some of these coatings have good dielectric strength, as well as fatigue and thermal shock resistance. They can be heated to 1700°F and quenched in cold water for at least 10 cycles without damage.

In formulating for premium alloys, refractories are usually added to gain additional heat protection. Often high-firing cobalt enamels are used with very high percentages of alumina to obtain coatings with optimum properties.

With use of appropriate refractory materials, the coating can be made either highly reflective or highly emissive. Thus the coatings can be used to reduce metal temperature. In effect, reflective coatings turn back some of the heat that would normally reach the metal, while emissive coatings help dissipate the heat from the metal. It has been found in many cases that reflective coatings can reduce metal temperature on the inside by as much as 200°F.

Coatings with the highest reflectivity or lowest in emissivity are those formulated with high percentages of dense, white oxide and low percentages of glass. Zirconium spinel and Treopax appear to be the best oxides for this purpose. Such coatings must be applied in much greater thickness than ordinary high temperature ceramics since they must be impervious to stray radiation from the base metals.

Coatings with high emissive, low reflective values, on the other hand, must be dark in color and have a rough and matte surface, and they are applied thin, one to two thousandths of an inch. Some refractories commonly used in coatings of this type are nickel oxide, chromic oxide, ferrosilicon and chromide.

In recent years, coatings have also made impressive inroads on reducing the more than $6 billion loss attributable to corrosion each year. As wider understanding of their protective properties is gained, their employment in this area should increase.

### *Performance of Ceramic Coatings*

An idea of the coatings' performance under severe mechanical and thermal shock conditions can be had from recent impact tests. When properly applied, the

*Fig. 3—Slushing is method of coating inside surfaces. Liquid is poured in thin stream from hose, allowing gravity to spread it. Considerable operator skill is also required here, for parts must be tipped and tilted to obtain good flow and even coverage.*

coatings do not require special handling. While a sharp blow may fracture the coating at the impact point, a thin protective film will remain.

Such spots will heal themselves during subsequent

*(Continued on page 34)*

# THE WHY AND HOW OF QUENCHING

By **CLARENCE A. SIEBERT,** Professor of Metallurgical Engineering
University of Michigan
Ann Arbor, Mich.

THE HEAT TREATMENT of steel has received considerable attention in the last thirty to forty years, and our knowledge of the factors affecting the decomposition of austenite has been greatly enhanced during this period. It is not the purpose of this article to discuss all of the factors affecting the hardening of steel, but rather to concentrate on the one factor of cooling, regardless of the hardening characteristics of the steel.

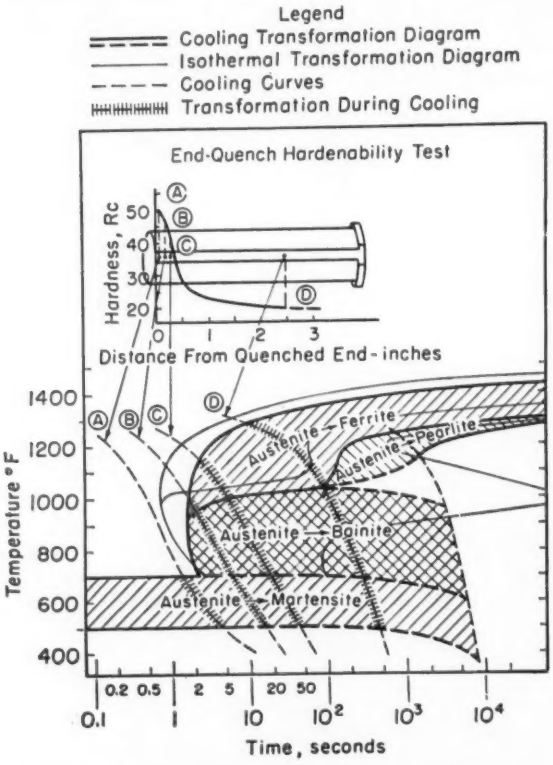


*Fig. 1—Correlation of continuous cooling and isothermal transformation diagrams with end-quench hardenability test data for an 8630 type steel. (Carilloy Steel Book)*

The why of quenching can be summarized in a few words. The steel is quenched to prevent the austenite from decomposing under equilibrium conditions thereby producing microstructures which alter the mechanical properties of the steel. If we cooled a hypoeutectoid steel under equilibrium conditions, the microstructure would be ferrite and pearlite, and the carbon content of the pearlite and the proportions of pearlite and proeutectoid ferrite would be those corresponding to the phase diagram of the steel. This, naturally, would be a function of the alloy content of the steel, as the effect of alloying elements on the carbon content of the pearlite is to shift the carbon content to a lower value than that of the plain iron-carbon alloy. However, when this same steel is cooled at a faster rate than that necessary to produce equilibrium conditions, the austenite will decompose at subcritical temperatures. The resulting microstructure will have less proeutectoid ferrite and more pearlite, and the carbon content of the pearlite will be less than that of the equilibrium structure. As the rate of cooling is increased the austenite decomposes at lower temperatures, and the pearlite becomes increasingly finer. The rate of cooling may be increased to the extent that the proeutectoid ferrite and pearlite are suppressed and only bainite and/or martensite are formed. Fig. 1[1] shows an isothermal transformation, and a cooling transformation diagram for an 8630 steel. Cooling according to curve A results in a microstructure of all martensite. Cooling histories represented by curves B through D result in a structure of ferrite, bainite, and martensite with increasing proportions of ferrite and bainite in the structure as the cooling progresses from B to D. This, in turn, has a marked influence on the mechanical properties of the steel.

The word quenching, when applied to the heat treatment of steel, covers the process of cooling the steel from the austenitizing temperature at such a rate that the decomposition of the austenite will occur at subcritical temperatures. The quenching medium can be a gas, liquid, or solid, the latter being water cooled quenching dies. The quenching problem is one of heat

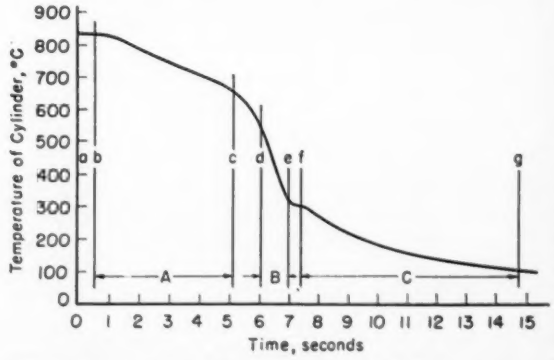


*Fig. 2—Manner in which a water-quench lowers the surface temperature of a piece being quenched at successive stages of the quench. (Pilling and Lynch)*

[1] U. S. S. *Carilloy Steel Book*, 1948, page 31.

transfer. The quenching medium extracts heat from the surface of the steel which results in a temperature gradient being set up in the body of the steel and heat to flow in the body to the surface of the steel.

Pilling and Lynch[2] conducted an extensive investigation on quenching and determined that three distinct stages of cooling occur when the quenching is done in a medium which undergoes vaporization during part of the quenching cycle. Fig. 2, reproduced from their work, shows the cooling curve of the center of a small cylinder quenched into water. It is immediately apparent that the cooling rate, that is, the slope of the curve at any given temperature, is a variable with temperature. The first stage A is the vapor blanket stage. This is the stage where the water is vaporized and a steam blanket surrounds the steel. Heat transfer under this condition is rather slow. Stage B represents the condition where the water reaches the surface of the steel and is vaporized thereby extracting greater amounts of heat due to the latent heat of evaporation. Stage C occurs when vaporization no longer occurs and the heat transfer is through the liquid film on the surface of the steel. The rates of cooling in this stage are slower than those encountered in Stage B. Grossmann[3] replotted the data of Fig. 2 to show rates of cooling and this is shown in Fig. 3. It can be seen that the rate of cooling increases with decreasing surface temperature, reaching a maximum at approximately 450°C, and then decreases with further decreasing surface temperature.

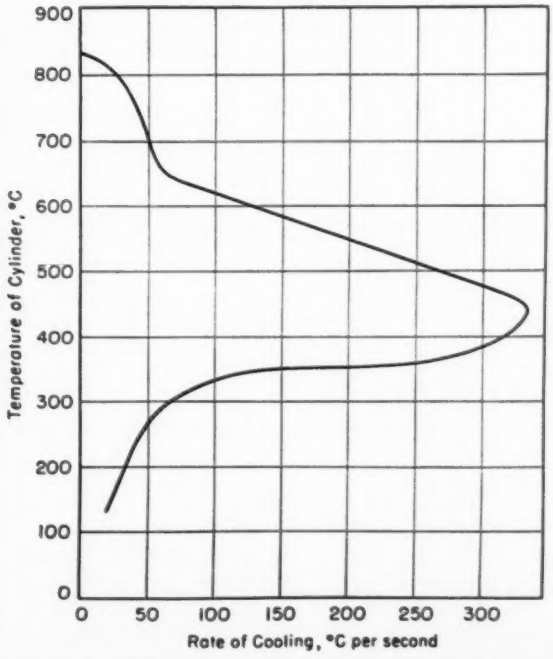


*Fig. 3—The data of Fig. 2 re-plotted to show rates of cooling instead of times of cooling.*

From the above discussion it is clearly evident that the quenching of steel falls into the category of unsteady state heat-transfer. The temperature of the steel, the coefficient of heat-transfer, the specific heat, and the thermal conductivity are changing in the quenching process as well as the crystalline structure which has an effect on some of the above variables.

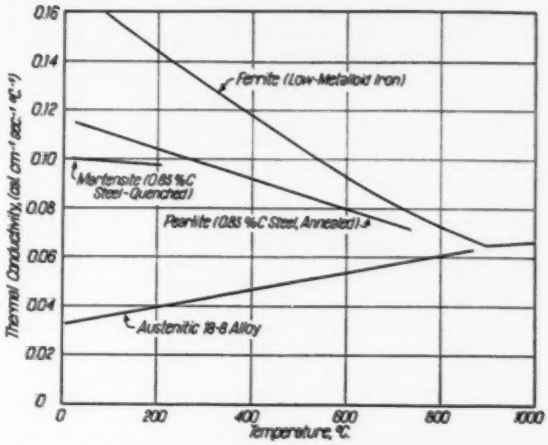


*Fig. 4—The thermal conductivity of ferrite, pearlite, martensite, and austenite.*

Newton's law of unsteady state heat transfer is applicable to the quenching of steel. However, in attempting to handle this complex problem many investigators have resorted to simplifying assumptions to arrive at an approximate answer to the problem.

Russell[4] prepared a useful set of tables for coping with unsteady state heat transfer problems utilizing the assumptions that H, the severity of the quench, and a, the thermal diffusivity, are constants. These constants are defined as follows:

$$H = \frac{C}{k}$$ when C = coefficient of heat transfer, k = thermal conduction

$$a = \frac{k}{s\rho}$$ s = specific heat, $\rho$ = density

One of the factors involved in hardenability calculations of steels is the so-called quenching constant H. However, we must remember that the assumption of a constancy of diffusivity has a direct bearing on the quenching constant H. It is therefore desirable to examine the effect of temperature on the various factors which are incorporated into the constants.

[2] N. B. Pilling and T. D. Lynch, "Cooling Properties of Technical Quenching Liquids", *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 62, 1920, page 665.

[3] M. A. Grossmann, *Elements of Hardenability*, published by American Society for Metals, 1952, page 63.

[4] T. F. Russell, "First Report of the Alloy Steels Research Committee," Special Report 24 of the Iron and Steel Institute, 1936.

The three stages of cooling described above have three widely different values of coefficients of heat transfer. The coefficients for the vapor stage are small, those for the evaporation stage are high, and those for the liquid stage somewhere between the values of the vapor and evaporation stages. For moderate size pieces the first and second stages of quenching are accomplished in a small fraction of the time necessary to cool

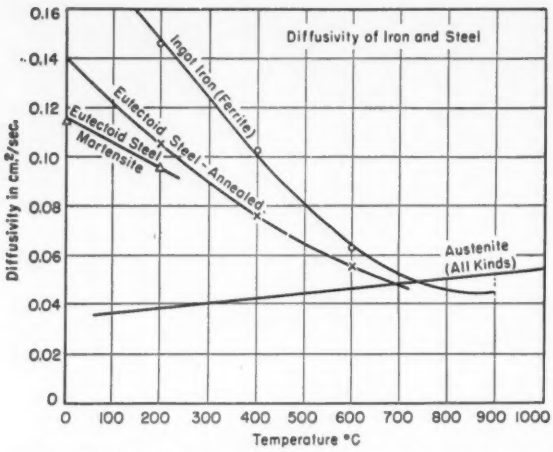


*Fig. 5—Diffusivity of various structures at a series of temperatures, in square centimeters per second, degrees Centigrade. (After Austin)*

the entire piece and the majority of the heat is extracted during the third stage of cooling. While the coefficient of heat transfer in the third stage still varies with temperature, the change is small compared with the change from the second to the third stage of cooling.

The effect of temperature on thermal conductivity according to Austin[5] is shown in Fig. 4. It can be seen that the conductivity of austenite increases while those of the decomposition products decrease with increasing temperature. The problem is further complicated by the fact that austenite and decomposition products exist at the same time as soon as decomposition starts in the piece being quenched.

Grossmann[6] presented diffusivity data which are shown in Fig. 5. The diffusivity of austenite increases and that of the decomposition products decrease with increasing temperature. Diffusivity values of 0.058 to 0.064 $cm^2$/sec. appear to fit experimental results to a fair degree of approximation. The variation of specific heat and density with temperature and crystalline structures are reflected in the diffusivity values.

Carney and Janulionis[7,8] made an extensive study of the quenching constant H from cooling curve data obtained on 18-8 austenitic steel. The use of an austenitic steel minimized the temperature effect on thermal conductivity and diffusivity as well as the complication introduced by the heat evolved when austenite transforms into its decomposition products. They used Russell's tables to evaluate H. Some of their results are shown in Figs. 6-10. They have included a sample calculation in reference[7].

Fig. 6 shows the H values for various sized rounds, quenched into water, as determined from cooling curves placed at the center of each of the rounds. You will note that the H value for the ½" round is not constant at any of the terminal temperatures. For the larger size rounds, the H values become substantially constant for terminal temperatures below 1200°F. However, the H value decreases with increasing diameter of the bar.

Fig. 7 shows the H values determined by quenching various sized rounds into oil. It can be seen that the H values vary with the terminal temperature and also decrease with increasing size of the round. Fig. 8 shows the H values obtained on water quenching a 3" round as a function of the placement of the thermocouple within the bar. It can be seen that the H value varies with the position of the thermocouple, decreasing as the position of the couple varies from near the surface to the center of the bar.

They also included some data on 1080 and 9460 steels. These data are reproduced in Figs. 9 and 10. You will note that the difference in H values as affected by size is not as great for the 1080 steel as that en-

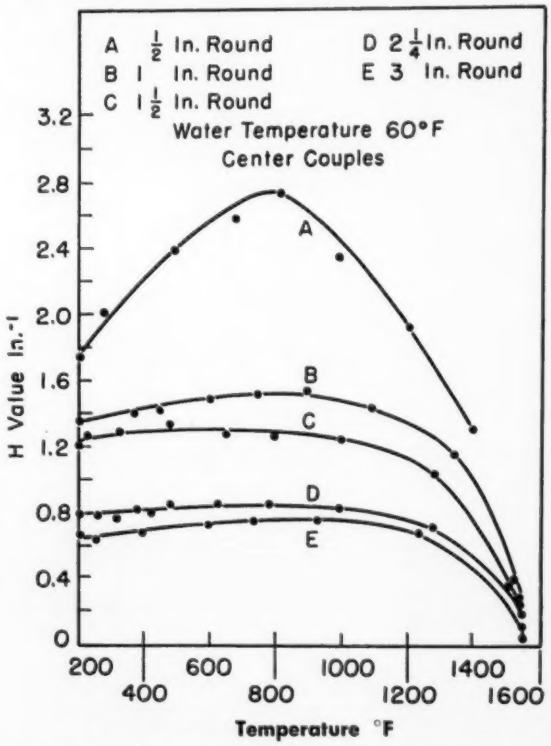


*Fig. 6—Effect of temperature and size on H value for 18-8 water quenched from 1550°F.*

(5) J. B. Austin, *The Flow of Heat in Metals*, published by American Society for Metals, 1942, page 50.

(6) M. A. Grossmann, *Elements of Hardenability*, published by American Society for Metals, 1952, page 91.

(7) D. J. Carney and A. D. Janulionis, "An Examination of the Quenching Constant, H," *Transactions*, American Society for Metals, Vol. 43, 1951, page 480.

(8) D. J. Carney, "Another Look at Quenchants, Cooling Rates, and Hardenability," *Transactions*, American Society for Metals, Vol. 46, 1954, page 882.

countered in the austenitic stainless steel. It can also be seen that the difference in H values for the various sized bars is greater for the 9460 steel than for the 1080 steel. The same value of diffusivity was used in calculating the H values for all of these steels. Some of the difference between the 18-8 and hardenable steels can probably be attributed to the fact that a decomposition of the austenite occurred in the 1080 and 9460 steels which would have a marked effect upon the diffusivity factor. The differences noted for the 1080 and 9460 steels can be partly due to the greater hardenability of the 9460 steel and the temperature at which the decomposition of austenite occurs.

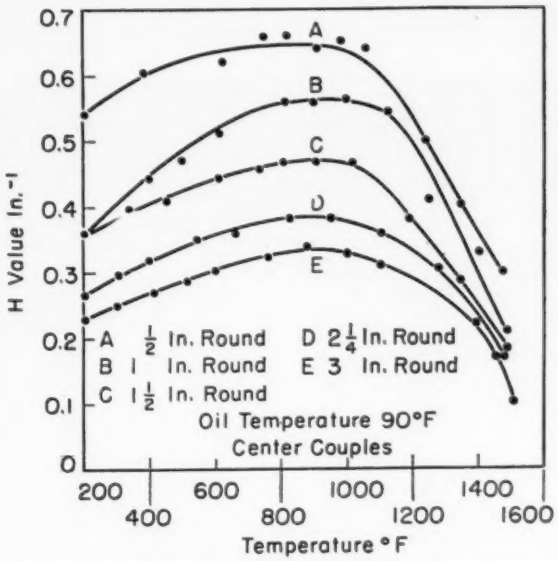


*Fig. 7—Effect of temperature and size on H value for 18-8 oil quenched from 1550°F.*

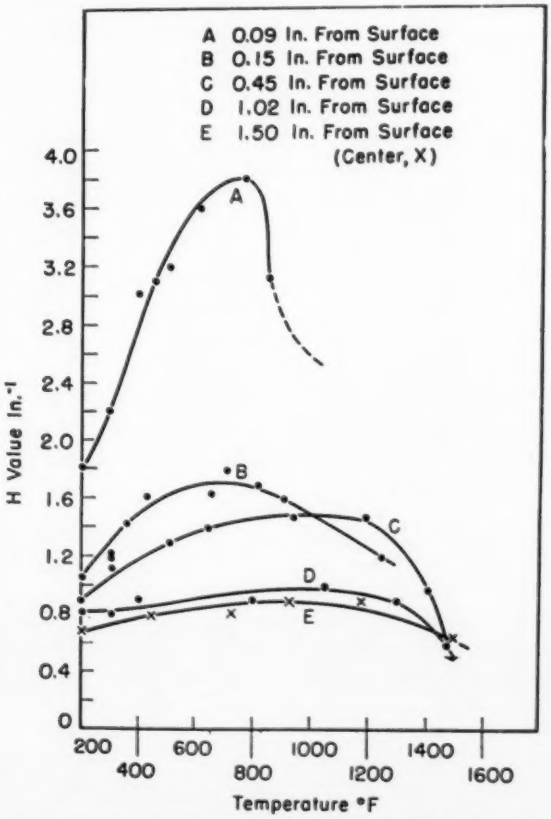
A 0.09 In. From Surface
B 0.15 In. From Surface
C 0.45 In. From Surface
D 1.02 In. From Surface
E 1.50 In. From Surface
(Center, X)
H Value In.⁻¹
Temperature °F

*Fig. 8—Change of H value with distance from quenched surface of a 3" round of 18-8 quenched in water at 60°F.*

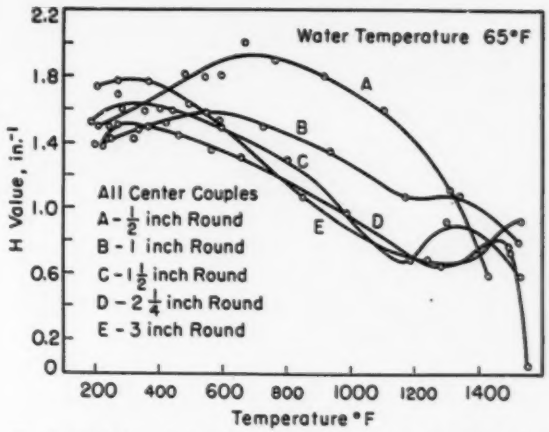
Water Temperature 65°F
All Center Couples
A - ½ inch Round
B - 1 inch Round
C - 1½ inch Round
D - 2¼ inch Round
E - 3 inch Round
H Value, in.⁻¹
Temperature °F

*Fig. 9—Variation of H with temperature and size for 1080 water quenched from 1550°F.*

The severity of the quench, H, is an integral part of hardenability considerations. Hardenability considerations are based upon the assumptions that equal cooling histories in various sized rounds of the same heat of steel will produce the same microstructure and therefore the same hardness value. The criteria for equal cooling histories are based upon the rate of cooling at 1300°F, time to half temperature, or some other base for comparison. The microstructure is taken as some fraction of martensite plus high transformation

*(Continued on page 43)*

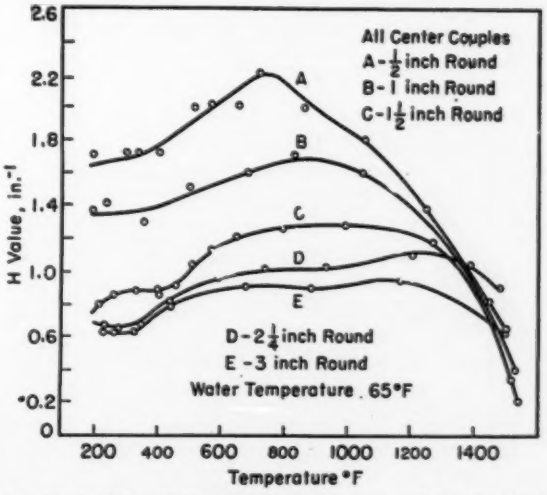
All Center Couples
A - ½ inch Round
B - 1 inch Round
C - 1½ inch Round
D - 2¼ inch Round
E - 3 inch Round
Water Temperature 65°F
H Value, in.⁻¹
Temperature °F

*Fig. 10—Variation of H value with temperature and size for 9460 water quenched from 1550°F.*

# CONTINUOUS STRESS-RELIEF OF TRANSFORMER LAMINATIONS

By **ANTHONY NICHOLLS,** Information Officer
Metalectric Furnaces, Ltd.
Smethwick, England

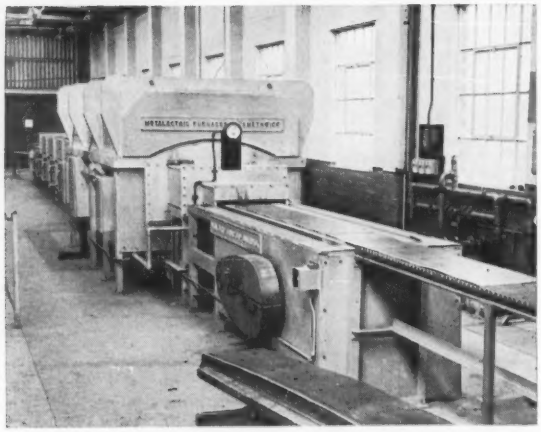

*Fig. 1—Charge end of continuous stress-relieving furnace at the works of British Thomson-Houston Co., Ltd., Rugby, England.*

THERE IS AN increasing demand in industry for continuous manufacturing processes, to replace batch production. The industrial furnace designer is constantly reviewing established practice to see whether improvement is possible. A good example of the results achieved by such reconsideration may be seen in the process of stress-relieving cold-rolled silicon steel transformer laminations.

In Britain, as in the United States, it has for some years been standard practice, after the stamping operation, to stress-relieve the sheet in a lift-off furnace. One of the requirements in the manufacture of these stampings is a high 'space factor': buckling and 'rivelling' of the edges of the sheet are bound to make a bulky transformer. The lift-off furnace has normally been used for their heat treatment since it allows the careful placing of packs of laminations which are then left undisturbed throughout the heating cycle.

## Lift-off Method

As soon as the process is considered carefully, it becomes clear that the lift-off furnace has several serious disadvantages. Considerable difficulty is experienced when loading the furnace. The stampings vary considerably in length and width, and production methods are such that there is very seldom a furnace load of one size of stamping. Great skill and care are necessary to fit the greatest number of stampings on the furnace base while allowing good heat transfer to the load, and thus avoiding distortion of the stampings.

Also, even if production methods were such as to give a large number of the same size sheets at the same time, it would be undesirable to have an unbroken stack of stampings reaching the full piling height of the furnace; heating up and cooling would be extremely slow. Moreover, this cannot be overcome by increasing the heating rate since this gives rise to serious distortion of the sheet.

It is worth noting that the adoption of a slow heating and cooling cycle does not completely cure this trouble, although it does reduce it to some extent. In practice steel spacer pieces are placed every six to eight inches to separate the packs and allow heat transfer vertically as well as by edge heating. The next pack is then supported on a steel plate to reduce distortion. Thus a considerable weight of steel is uneconomically heated in each cycle. To ensure complete soaking of the stampings, the spacer pieces and the furnace cover require a 45-50 hour cycle.

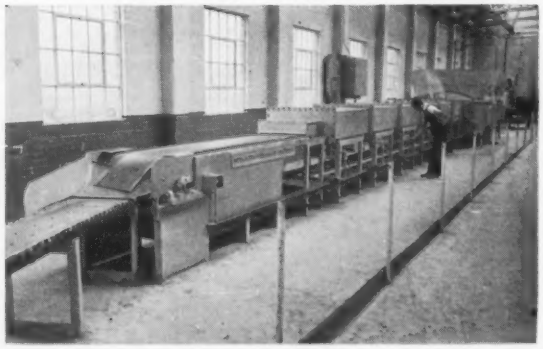

*Fig. 2—Discharge end of the furnace.*

This length of cycle brings a further difficulty. Carbon is an undesirable impurity in electrical sheet, and the manufacturer aims at reducing it to a very low level: certainly below 0.008%. Such sheet is of course highly susceptible to carbon pickup during heat treatment; the atmosphere must therefore be non-carburizing especially since the sheet is in contact with the atmosphere for a long period. For this reason an atmosphere derived from cracked and burned ammonia —not the cheapest of atmospheres—is required for a lift-off furnace.

*(Continued on page 10)*

# New Protection For YOUR Equipment— At Temperatures Up To 3300°F

*ALUNDUM* castables offer unusual advantages to all industries using high temperature installations*

**Will fire continuously up to 3300°F.** This Harrop gas-fired furnace, recently developed by the Electric Furnace Division of the Harrop Ceramic Service Company, Columbus, Ohio, is particularly applicable to the firing of ceramic oxide bodies. Norton ALUNDUM 33-I Insulating Castable selected for the inner lining of the furnace and its roof, provided completely satisfactory protection under repeated tests at highest operating temperatures.

The new Norton ALUNDUM Castables are made in two types: 33-I Insulating and 33-HD Heavy Duty. At temperatures up to 3300°F both types have been extremely successful in protecting high temperature processing — in many industries and many different installations.

ALUNDUM 33-I Insulating Castable is made up primarily of pure aluminum oxide bubbles, tiny and countless. Forming a network of air spaces, it assures excellent insulation, even at highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in many types of furnaces where high temperature conditions are particularly severe.

Both 33-I and 33-HD Castables are very easy to store, mix and use. With them you can cast simple or complex shapes quickly and economically, replace more expensive pre-fired shapes, and cut maintenance and replacement costs to very lowest. Ask your Norton Representative for details, and for the folder *Two Norton Castables.* Or write to NORTON COMPANY, Refractories Division, 626 New Bond Street, Worcester 6, Massachusetts.

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## CONTINUOUS STRESS-RELIEF

*(Continued from page 8)*

On many counts then, the traditional method seems far from ideal: and Metalectric Furnaces Limited, Smethwick, England, who have built a considerable number of lift-off furnaces, were led to the conclusion that a continuous furnace might have many advantages.

### *Continuous Furnace Method*

Several advantages seemed possible: first a very great reduction in the time cycle—always an important point for production schedules; second, a cheaper form of atmosphere could be used because the shorter heating time would bring a great reduction in the risk of carbon pickup; third, a much better flow of work would be possible because a continuous furnace could be designed to suit the maximum width of sheet and variations in length would be unimportant; and fourth, a considerable fuel saving was likely because there would be no spacer pieces and steel plate to heat up.

Accordingly, Metalectric engineers carried out a series of tests on a continuous furnace arranged to use any industrial controlled atmosphere. In this way it was possible to compare the effect of various atmospheres on the physical and electrical properties of the sheet. By arrangement with one of the leading manufacturers of electrical equipment, matched pairs of test pieces were cut from sheet: one test piece in each pair was stress-relieved by the manufacturer's usual method; the other was heat treated in a continuous furnace. The samples were then tested and compared.

### *Test Samples Compared*

The results showed conclusively that the long cycle lift-off process was unnecessary. The continuously treated test pieces were in much better physical condition than those from the batch process. In electrical tests there was less difference; nevertheless there was still a slight advantage in favor of the continuous process.

The next step clearly was to stress-relieve sufficient stampings to build a complete transformer. This was necessary to prove the method and also to show that the higher heating and cooling rates obtainable in the continuous process had no deleterious effects on the laminations. The experiment was completely successful; an important point was that the laminations were completely flat, and the atmosphere used was only one-fifth the cost of the cracked and burned ammonia.

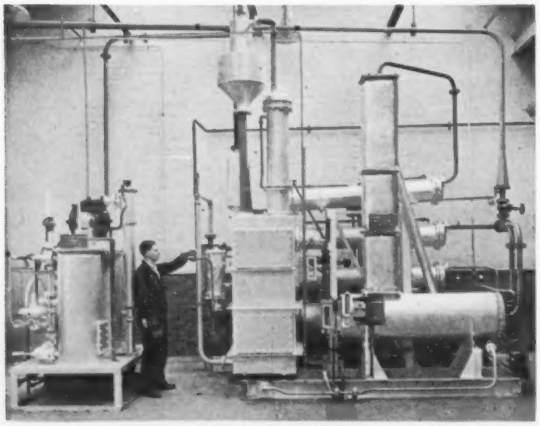


*Fig. 3—1,000 cubic feet per hour Hi-Nitrogen plant.*

Metalectric Furnaces Limited have now built a large number of continuous furnaces for this work, with outputs ranging from 20 to 60 long tons per week. Experience gained on these plants has shown that while the total cost of stress-relieving in lift-off furnaces varies between $24.00 and $30.00 per long ton, in the continuous furnace the cost is from $16.00 to $22.00 per ton: a very substantial saving.

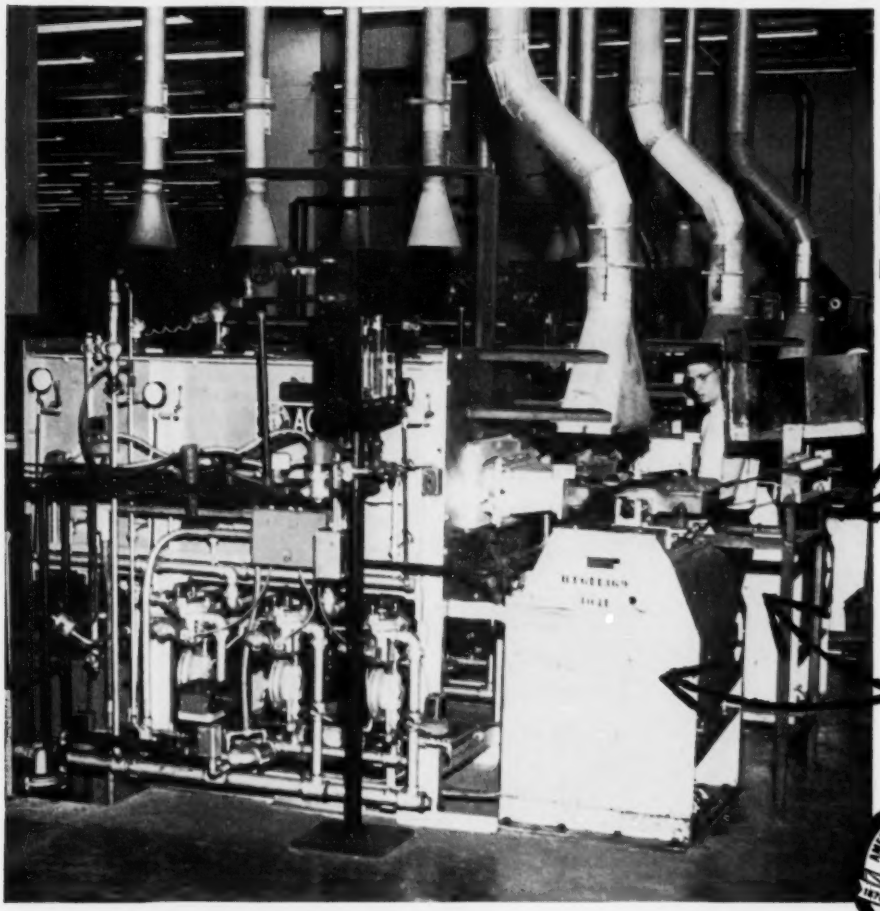
### *Typical Continuous Furnace*

A typical furnace for this work is shown in Figs. 1 and 2. It is installed at The British Thomson-Houston Company Limited, Rugby, England. The overall length of the furnace is 60 feet, and the heating section has two separately-controlled zones. The nickel-chromium tape elements are fitted to the sides and hearth of the chamber, and are rated at 120 kw. Although the normal working temperature is 1500°F, the furnace is designed to operate up to 1650°F. The cooling section is water-jacketed and is mounted on rollers to allow for expansion. The conveyor is 26" wide to handle laminations up to 24" wide. It is driven by a variable speed gear, and the usual belt speed is 1 foot per minute, giving a complete cycle from charge to discharge of 1 hour, compared with the 40 hours or more of the batch process. Output at this speed is 450-500 lbs. per hour.

The laminations are loaded directly on to the conveyor in shallow packs; there is thus a much greater heat transfer rate in this furnace than obtains in the lift-off furnace with its thicker packs. The laminations travel through an inlet canopy designed to reduce controlled atmosphere losses, then through a vestibule which acts as a heat seal, and so through the regulated heat and soak zone, through the cooling zone and the outlet canopy on to a roller conveyor.

The protective atmosphere is supplied by a Hi-Nitrogen plant manufactured by the Incandescent Heat Company Limited, Smethwick, under license from Gas Atmospheres Inc., Cleveland, Ohio. It produces 1,000 cubic feet of nitrogen per hour (Fig. 3). Air is inspirated and mixed with sufficient fuel (in this case town's gas) to give complete combustion and thus remove the free oxygen in the air. The products of combustion are then bubbled through monoethanolamine which absorbs the carbon dioxide; and the remaining gas is passed through a dryer which removes the water vapor, leaving dry nitrogen. In normal operation, a dewpoint of minus 30°F is consistently obtained; lower dewpoints can be obtained if necessary. • • •

# PRODUCTION HEAT TREATING



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**Editor's Note:** This is the final article on this topic of a two-part series which began in the last issue. It has been abstracted from the book *Modern Principles of Heat Treatment of Steel* just published by Uddeholm Company of America, Inc., who furnished the photographs and granted permission to publish the articles.

## SOME FACTORS INFLUENCING THE FORM OF THE TTT-DIAGRAM

Many TTT-diagrams have been compiled during recent years and among these are represented all of the more important types of steels. A good picture of the different factors influencing the form of the curve can be obtained. The most important factor is the composition of the steel. With more highly alloyed steels the rate of austenite transformation is reduced and the curves move further to the right of the diagram. Another important factor is the temperature from which the steel is cooled, termed the austenitizing temperature. A higher austenitizing temperature causes the steel to transform more slowly and this also pushes the curve to the right.

Figs. 1 and 2 show TTT-diagrams for two "non-deforming" steels. SAE 01 is low alloyed whereas SAE D6 is of the high carbon-high chromium type. A typical feature of this latter steel is the disconnected curves and ranges of pearlite and bainite. Note also the long time required for the transformation of this steel compared with unalloyed steel.

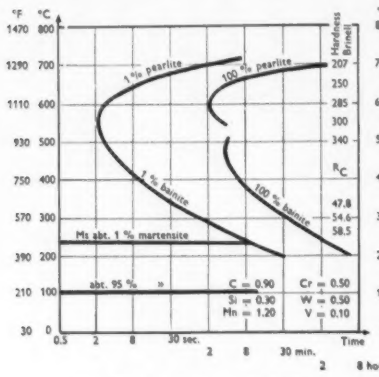


*Fig. 1—TTT-diagram for SAE 01.*

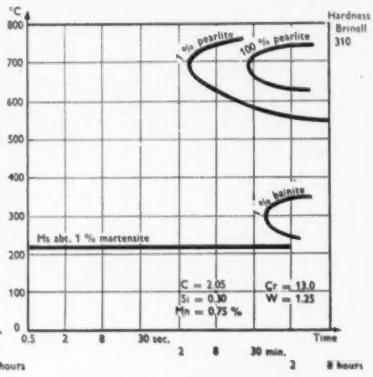


*Fig. 2—TTT-diagram for SAE D6.*

### *Practical Aspects of the TTT-Diagram*

Tools and constructional parts which are subject to heat treatment are mostly very much larger in size than the small test pieces on which the TTT-diagrams are based. The cooling therefore takes place not instantaneously but gradually over a certain length of time on account of the great thermal capacity of the components. It might appear that such a curve based on laboratory work is of little practical help to the steel user. There is, however, a certain parallel between the transformation of austenite at constant temperature and its transformation on cooling which makes the TTT-diagram a valuable guide for heat treatment, principally for hardening. The following heat treatment procedures will be discussed in relation to the TTT-diagram.

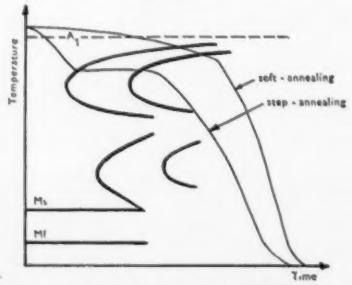


*Fig. 3—Principle of the TTT-diagram showing soft-annealing and step-annealing.*

### *Soft Annealing and Cyclic Annealing*

Tool steel allowed to cool in air after rolling or forging often becomes too hard to allow easy machining. To reduce hardness, the steel is soft annealed (or full annealed). With most tool steels the practice is to heat to a temperature slightly above $A_1$, to allow solution of carbon to take place, forming austenite. It is then allowed to cool very slowly, usually 15°-30° per hour to 1200°-1110°F.

If this is now drawn as a time-temperature diagram with the TTT-diagram of the steel in question (Fig. 3), it can be seen that the transformation takes place completely in the upper part of the pearlitic field. A reduction in the rate of cooling causes transformation at a higher temperature and a softer structure. The length of time cooling at above $A_1$ should be kept as short as possible as no transformation takes place here. Use is made of this fact in *cycle annealing* (or step annealing or isothermal anneal) where the steel is allowed to cool down to the appropriate temperature which is then kept constant. By this method a certain amount of time is gained, but the resulting hardness is not as low as that obtained by soft annealing. Unalloyed steels of carbon content lower than 0.90 per cent are annealed in a different manner. The steel is heated to a temperature just below $A_1$ and kept at this heat for several hours. The pearlitic structure is then slowly formed into a soft annealed structure (spheroidized pearlite) without any actual transformation taking place in the steel.

### *Normalizing*

Normalizing is used to give a fine grain structure particularly to unalloyed and low alloyed constructional steels. The steel is heated to a temperature above 1700°F, followed by cooling freely in air. This procedure involves two transforma-

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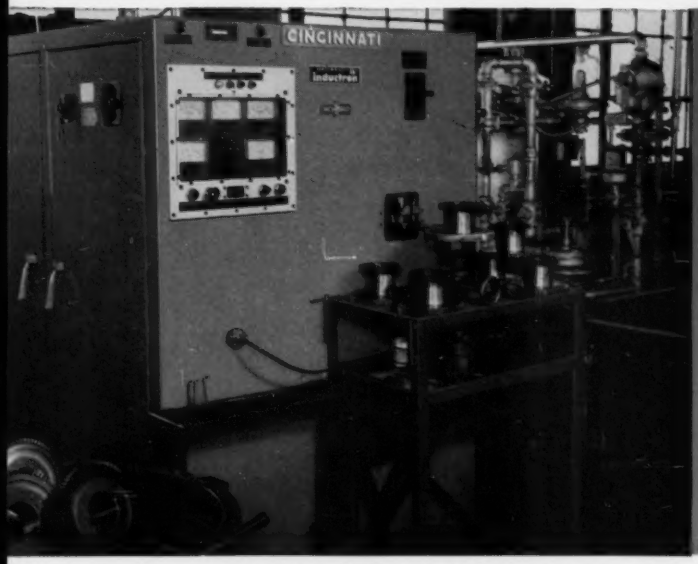
*at Cincinnati Steel Treating Co.*
*the most versatile machine*
*in the shop is a*

# Cincinnati Inductron




**CINCINNATI 30KW INDUCTRON** induction heating machine in the plant of the Cincinnati Steel Treating Co. The part being processed is an SAE 4145 spur cluster gear. Hardening time for the 8" dia. gear is 21 seconds; the 4½" dia. gear is 18 seconds.

**FACE SPUR GEAR** of SAE 4615, carburized, 8½" dia. x 1⅛" face width, hardened in 30 seconds.

**SHAFT** of SAE 1043, 1⅜" dia. x 3¼" long, hardened in 18 seconds.

**SPIRAL PINION** of SAE 4645. Gear section, 4" dia. x 4" long, hardened in 45 seconds.

**LOCKING PAWL** of SAE 1045. Locking tip hardened in 4 seconds.

**PIN** of SAE 1045, 1½" long, hardened in 4 seconds.

A wide variety of parts, in job-lot quantities, are precision selective surface hardened at Cincinnati Steel Treating Co., on a 30KW capacity Cincinnati Inductron®. The several parts shown here are typical of the variety of work that is processed daily.

The Inductron operates at frequencies up to approx. 1200KC; provides rapid heating with minimum distortion and scale. With its variable output RF transformer, output can be varied under load from 30% to 100% of rating. Thus a single work coil can be "tuned" to the work by positioning a small, graduated dial, and within reasonable limits, can accommodate parts of different sizes and configurations. This high versatility, plus long component life and ease of maintenance, were the advantages that made the Cincinnati Inductron *first choice* of this most modern heat-treating plant.

Cincinnati builds *both* Inductron (15, 30, 50KW) induction heating machines, and Flamatic® flame heating machines . . . in automated units for high production, or equipped for a variety of short-run work. For detailed information on machines exactly tailored to your heat processing requirements, write direct, or call in a Meta-Dynamics Division field engineer.

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CINCINNATI

*(Continued from page 12)*

tions; one on heating and again on cooling, and gives a fine grain structure with good mechanical properties and machinability. Normalizing is only used for steels which are transformed completely in the pearlitic range imparting a structure which is not too hard to allow machining. For tool steel, this method is of very limited interest.

### *Stress Relief Anneal*

Before a tool is hardened, particularly if of complicated form, it is often advantageous to anneal to relieve stresses. The method is to heat to about 1200°F until completely

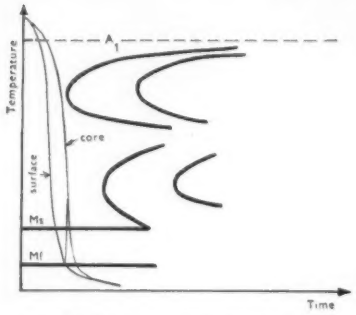


***Fig. 4—Principle of the TTT-diagram showing the conditions on the surface and in the core of a quenched specimen subjected to ordinary hardening.***

heated through, then cool in the furnace to about 930°F. After this the tool is allowed to cool freely in air. No transformation takes place, of course, but the stresses set up by the previous machining are relieved and the risk of distortion in hardening is reduced.

### *Hardening and Tempering, Hot Quenching*

The standard method of heat treatment involves heating the steel to the proper hardening temperature, followed by quenching in water or oil. Carbon steels must be quenched as quickly and intensely as possible to obtain full hardness, generally in water or brine. Many low-alloy steels can be quenched in oil and more highly alloyed steels may be quenched in an airjet or even left to cool in still air. Every type of steel requires a certain minimum rate of cooling to achieve the highest hardness. The TTT-diagrams show the reason for this and also indicate the effect of insufficiently rapid cooling.

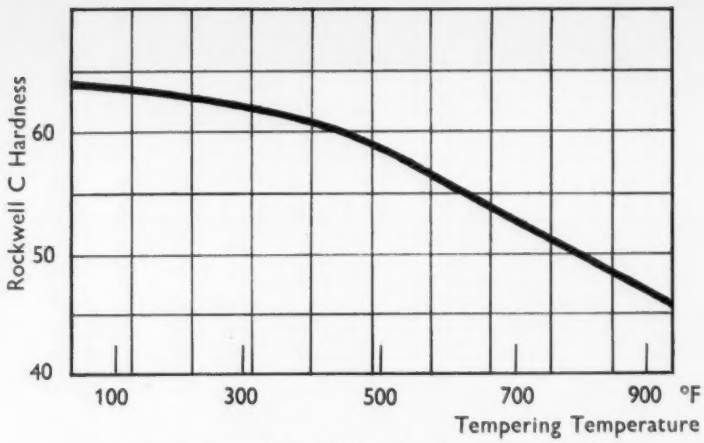


***Fig. 5—Tempering graph for SAE O1. Quenched in oil from 1470°F.***

An imaginary diagram, Fig. 4, shows side by side the surface and core temperatures of an object being quenched in a liquid of room temperature. The cooling is so rapid that no transformation into either pearlite or bainite has taken place. If the cooling had been too slow, the cooling curves would have cut across the lines in the transformation curves. These curves thus give a certain measure of the hardenability of the steel. The farther to the right of the diagram they lie, the larger the size of the steel bar may be and still achieve full hardness. When the surface of the object reaches Ms temperature, the martensite transformation starts until at Mf the surface is completely martensitic. At this point, however, the core is still hot enough to be completely austenitic, as can be seen from the vertical line between the cooling curves. The core will therefore become martensitic at a later

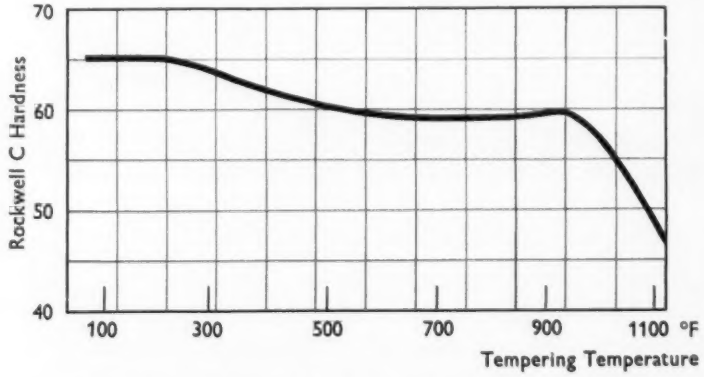


***Fig. 6—Tempering graph for SAE D2. Quenched in oil from 1830°F.***

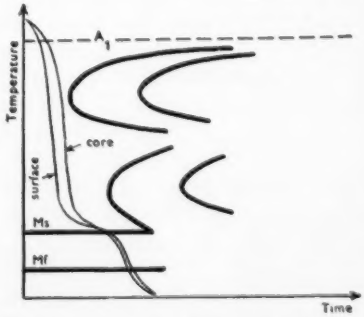


***Fig. 7—Principle of the TTT-diagram showing the conditions on the surface and in the core of a quenched specimen during step-quenching.***

stage than the surface; this fact involves a great risk because mar-

*(Continued on page 38)*

**AUGUST**—Selected supplier of anhydrous ammonia . . . assuming that service included technical advice "during use".

**LATER**—Ammonia system installed without supervision . . . not tested by supplier . . . some parts not designed for ammonia use.

**STILL LATER**—Had improper atmosphere mixture . . . undesirable case properties . . . sooting and added handling of "finished" parts.

**TOO LATE**—Too many rejects . . . supplier unable to aid on application. Labor, material and operating costs up . . . profits down.

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*a problem in labor arbitration taken from the files of the American Arbitration Association*

### *The Case of the Easy-Going Foreman*

When business picked up in a textile mill, management decided they could use another foreman, and thought Ralph L., one of the lead men, was deserving of promotion. They offered him the spot and explained that although as foreman he would be outside the bargaining unit, the seniority he had accumulated in the past wouldn't be lost. Under the union contract, he could bump his way back into his old job if things got slow again.

Ralph agreed and the promotion went through. As things turned out, however, it was a mistake from management's point of view. He was "too easy" on the men and didn't get things done on time. The personnel manager considered transferring him back to the bargaining unit and his old job, but decided that would be bad for morale. And so, regretfully, the company fired him.

The union filed a grievance. At first the company argued that what management did with respect to a foreman didn't concern the union at all. "In any case," the personnel manager said, "Ralph's seniority protects him only in the event of layoff for lack of work. It doesn't prevent his discharge for incompetence."

Eventually, the case went to arbitration under the Rules of the American Arbitration Association.

### *What Would YOU Do?*

**THE AWARD:** The arbitrator said the rights Ralph acquired while within the bargaining unit survived his transfer to the foreman job. The grievance was therefore arbitrable. On the merits of the case, he added that the company's objection to Ralph was as a *foreman*, not as a *worker*. He therefore directed that Ralph be returned to his old job.

### *The Case of the Private Investigators*

After the theft of a few hundred pounds of copper tubing from a factory stockroom one weekend, management put a staff of investigators on the job. They arranged interviews on company time with all employees who might be presumed to have information shedding light on the subject. The investigators had no authority to discipline anyone. All they could do was gather the facts and report to management.

Although none of the men questioned was accused of the crime, one employee demanded that a union representative be present during the interview. When this request was rejected, a grievance was filed to determine whether the contract, which provided for union representation in discussing grievances, applied to an interview by criminal investigators as well.

"Of course it applies," argued the union business agent. "The investigators' report might lead to action that would affect a man's job. Besides, we don't like the way some of these investigators have been carrying on."

The company answered: "The grievance procedure provides for union participation. If anyone is hurt by the investigation, that will be the time to complain and no one will bar the union. The investigators have the right to work in private. There is nothing in the contract to prevent it and no one is deprived of his rights by this procedure."

Eventually, the case went to arbitration under the rules of the American Arbitration Association.

### *What Would YOU Do?*

**THE AWARD:** The arbitrator said the issue was not whether the union *should* have the right to sit in on investigations but whether the union *does* have the right, under the existing contract. He could find nothing in the contract or past practice which in any way curtailed the company's right in this respect; the grievance was therefore denied without prejudice, of course, to the right to process a new grievance if any action should be taken against an employee which was deemed unjustified.

**CAUTION:** The award in these cases is not an indication of how other arbitrators might rule in other apparently similar cases. • • •

# Tool Steel Topics

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As the result of its special annealed structure, developed and tested over a period of several years, Bethlehem's Lehigh H tool steel (AISI Type D-2) now leads the field in machinability among the high-carbon, high-chrome tool steels sold today. In impartial studies, the machinability of Lehigh H has been proved outstanding as a most economical grade for a wide range of difficult applications.

In addition to its better machinability, Lehigh H now has improved wear-resistance, because its vanadium content has been increased to 1 pct. Other important advantages of Lehigh H: improved carbide distribution and increased center density, based on U. S. Patent No. 2,809,109, issued to Bethlehem. Its uniform structure makes possible a better response to heat-treatment, and results in maximum service life for tools and dies, even in the most severe service.

Lehigh H is the D-2 type of air-hardening high-carbon, high-chromium tool steel, which is well known for minimum dimensional change in heat-treatment. For tops in machinability, and for all-around dependability and economy, be sure to order the new improved Lehigh H from your Bethlehem tool steel distributor.

# NEWS TO HEAT TREATERS...

### HIGH-SPEED SALT BATH

While unquestionably specialized, the field of the commercial heat treater is still a broad one—and growing broader every year. One has to know the advantages and disadvantages of all heat treating methods, and must have full working familiarity with many different metals and their alloys.

Because of the many stringent requirements of heat treating specialization, salt bath furnaces are playing increasingly important parts in commercial work. Their versatility; their greater production speeds; their ability to minimize distortion, warping and surface defects are among the factors recommending them to heat treaters.

The experience of Benedict-Miller, Inc., Lyndhurst, N. J. steel warehousers and specialists in the commercial heat treating of fine steels, is indicative of this trend. Having installed their first high-speed salt bath furnace just about two years ago, the managers of the firms' Heat Treating Division are enthusiastic about it.

"Our salt bath enables us to do the same amount of work in from 50 per cent to 75 per cent less time than was needed previously with our other equipment," states Horace G. Simonson, the company's hi-speed specialist and an expert of 18 years' experience.

With an atmosphere furnace, for instance, it took from 7 to 8 hours to handle the daily load of high-speed work. These loads are now processed in salt in from 2½ to 4 hours regardless of the size, shape or type of the work. Moreover, the work comes out cleaner, much more uniform and straighter.

*Fig. 1—Horace G. Simonson, Benedict-Miller's high-speed specialist (left) and Robert M. Bloss, manager of the firm's H. T. Division check a high-speed steel rack hardened in their Ajax HHR salt bath furnace.*

*Fig. 2—As shown above, daily production at Benedict-Miller, Inc. covers a wide variety of materials. Parts shown range from high-speed and milling cutters to steel pins, sleeves and many more, and of many different grades of steel. Daily quantities vary from one to 2,000 each of such parts. All are handled in their high-speed furnace at temperatures from 1750°F to 2350°F.*

"Heating in salt is naturally faster," Mr. Simonson continues. "This permits shortening our cycles. Also, it avoids oversoaking some of the work, particularly the larger sections, as was sometimes necessary with our old equipment. Still another advantage is that we can also do partial hardening in salt, whereas this could not be done before."

Benedict-Miller uses a salt that permits operating at any temperature between 1750° and 2350°F.

"We run all materials that fall within this temperature range and which will not create problems with plating in the bath on other materials," states Mr. Simonson. "We do get considerable fuming at the higher temperatures, but obtaining the wide operating range required by us as commercial heat treaters more than makes up for this inconvenience. Besides, the fumes are easily exhausted."

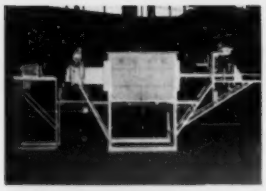
The new salt bath installation has proved especially valuable in hardening AISI-SAE T15 and other T-type high-speed steels with cobalt ($T_2$, $T_4$, $T_5$ and $T_6$.) "Prior to installing our high-speed salt bath, we would not attempt to harden such steels as Vasco Supreme, Grey Cut Cobalt and Red Cut Cobalt unless we knew that our customers had allowed for a minimum of .010" for grinding after hardening," says Mr. Simonson. "Otherwise, the decarburizing resulting from atmosphere-type heat treating would make things impractical.

"Steels of these types are now handled fast and efficiently in our salt bath. We merely place them in a preheat bath at 1100°F; transfer to a second preheat at 1550°-1600°F; then harden them in the bath at from 2225° to 2350°F depending on the part.

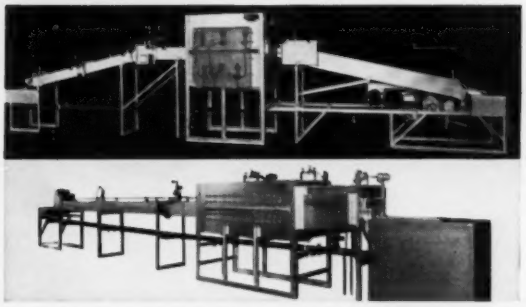
"Next they are hot quenched at 1050°-1100°F and air cooled. Finally the parts are tempered at 1025°-1050°F for a minimum of 2½ hours and redrawn at 975°-1000°F for a similar length of time. A hardness of Rc 66-68 is obtained consistently. Little if any finish grinding is ever required."

The Benedict-Miller furnace is an Ajax electric high-speed type HHR unit. Bath working dimen-

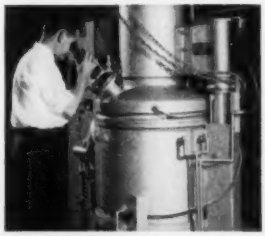
*(Continued on page 20)*



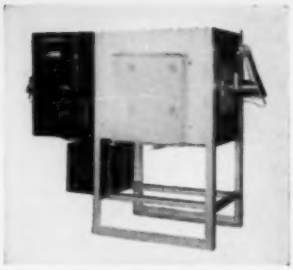
**HAYES TYPE M-Y HIGH-TEMPERATURE FURNACES** . . . provide uniform heating for sintering ceramics, cermets and refractory metals at temperatures over 3000°F. Economical — can be used with reducing atmospheres for close-control research or full-scale production.



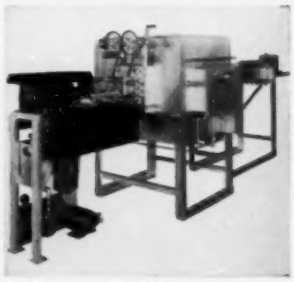
**HAYES CONVEYOR FURNACES** Types LAC (Straight Through) and BAC (Humpback®—Patented) . . . belt furnaces for continuous, automatic, uniform sintering of brass, bronze or iron compacts up to 2100°F. Available with zone temperature control . . . burn-off sections. For stainless steel work, etc.



**HAYES MODEL HT/HV VACUUM FURNACES** . . . high vacuum (0.1 micron), high temperature (3000°F plus) units for sintering special refractory metals — titanium, tungsten, zirconium, etc. Cold wall design. Low voltage elements. High-speed heating and cooling cycles.

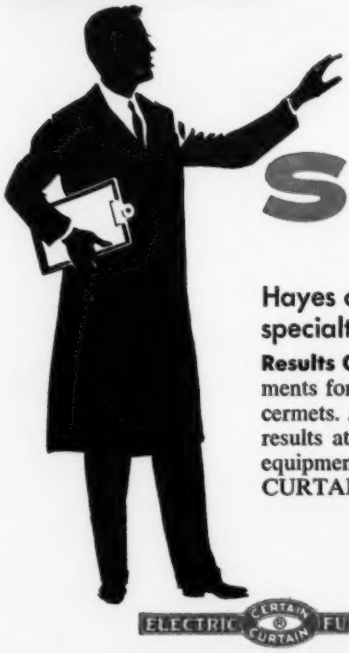


**HAYES TYPE BA-M PUSHER "Pilot Plant" FURNACES** . . . inexpensive, for controlled atmospheres, straight-through design, controlled temperature cooling chambers. Manual or automatic operation to 2150°F for sintering powder metal compacts.



**HAYES TYPE BA HIGH-PRODUCTION PUSHER FURNACES** . . . wide-temperature-range furnaces designed for special sintering applications to 2350°F. Used with varied atmospheres . . . available with automatic, electro-hydraulic pusher system to maintain constant time/temperature cycles for batch or production. Good for stainless steel.

**HAYES ATMOSPHERE EQUIPMENT** . . . Ammonia Dissociator (shown). Also a complete line of exothermic and endothermic generators, Molecu-dryers for drying protective atmospheres to —100°F D. P.



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*Company*.....

*Street*.....

*City*.....*State*.....

ELECTRIC CERTAIN CURTAIN FURNACES

# C. I. HAYES, INC.

Established 1905

816 WELLINGTON AVE. • CRANSTON 10, R. I.

*(Continued from page 18)*

sions are only 9" x 7½" x 30", these having been kept to a minimum for the type of work involved to avoid unnecessary heat loss at high temperatures.

Like most of the newer Ajax electric salt baths, this furnace has the new type R electrodes. These give all of the advantages of closely spaced submerged electrodes yet can be replaced in a matter of hours without tearing down furnace or pot.

During almost two years of continuous operation electrodes have been replaced twice with average life running between 8 and 10 months.

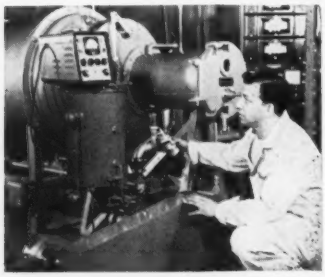
"This," adds Mr. Robert M. Bloss, manager of the Heat Treating Division, "is much better than we expected when we first started looking at high-speed salt baths." The original ceramic tile pot is still in the furnace.

*Source: TIPS AND TRENDS, Ajax Electric Co.*

***For further information circle No. 1***

### TUBE FURNACES

It is claimed that temperatures up to 5000° F can be reached in two hours and uniformly maintained throughout the heated length of the Hevi-Duty carbon-resistor tube furnaces, available in 6 standard sizes



ranging from 1" x 12" to 5" x 48" (dimensions refer to internal heated length). Close control and regulation of furnace temperatures are assured by use of a fully automatic saturable reactor control system.

***For further information circle No. 2***

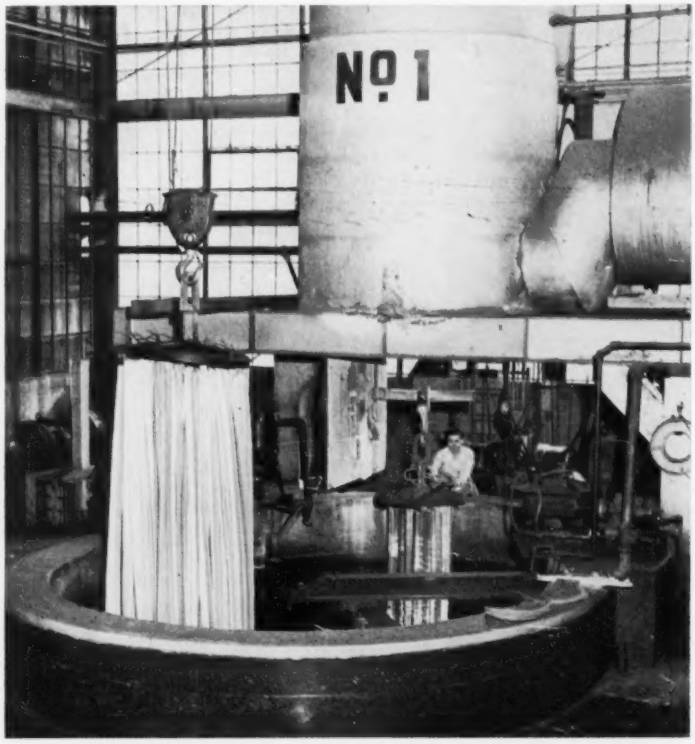
### DEIONIZED WATER "TEMPERS" ALUMINUM

In the heat treating of long aluminum extrusions Reynolds Metals Company at Grand Rapids, Mich., has installed a 96,000 gallon tank of deionized water as a quench bath.

A load of suspended aluminum extrusions is loaded into the 70 ft. high heat treating furnace and subjected to temperatures up to 980°F. Upon completion of the heat treatment, the metal is cooled quickly in a solution which will not stain the metal surface. Ordinary water cannot be used. A special quench tank was built directly under the furnace so that the hot extrusions could be lowered into the quench bath in the shortest time. The quench tank is a 12' x 15' oval, approximately 56 ft. in depth to accommodate the long extrusions.

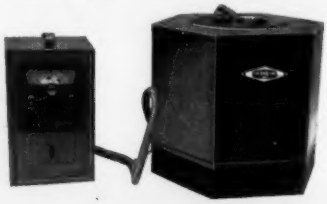
Deionized water is supplied to the tank from a multiple-bed ion exchange system. Amberlite ion exchange resins supply water rated at 3 P.P.M. dissolved solids, and having an electrical resistance of 200,000 ohms. This high-quality water protects the aluminum from stain by the quench, keeping the surface clean for further finishing.

***For further information circle No. 3***




### VERSATILE FURNACE

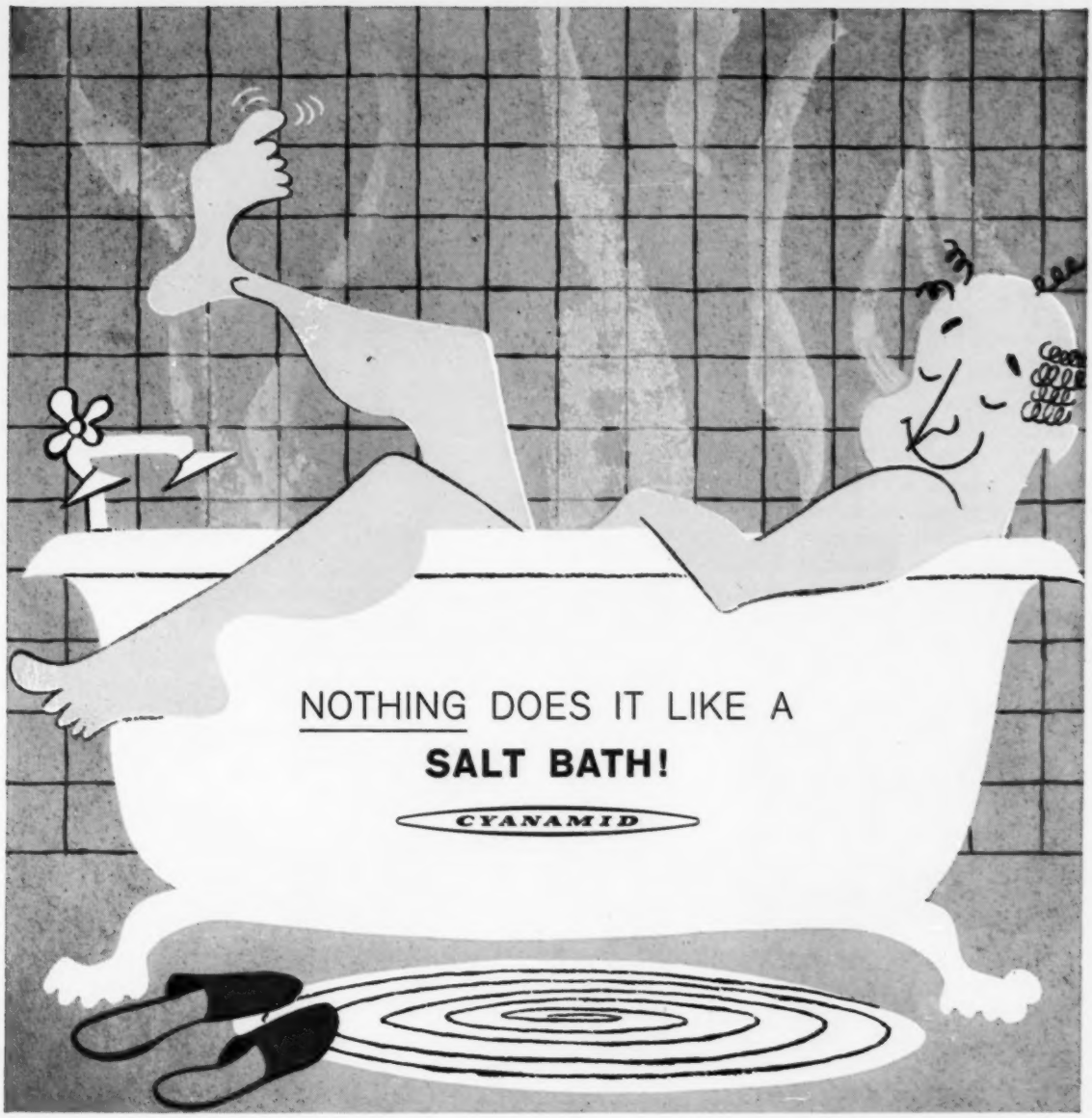
Thermo Electric Mfg. Co. has announced a new development in top-loading electric furnaces. The "Thermolyne" Furnace is a multi-purpose unit, adaptable for use as salt bath, melting, vertical muffle or crucible furnace.



Its many recommended laboratory shop uses encompass investigative and pilot runs as well as short run production and the heat treating of small parts. The maximum chamber temperature for intermittent operation is 1900°F.

The basic unit includes the hex-

*(Continued on page 22)*




There are other ways to heat treat metals, but nothing quite compares in *deep-down, over-all, satisfying* results with a Salt Bath.

For one thing, salt furnaces heat work faster and more evenly because temperatures are uniform throughout the bath. Too, salt baths *eliminate* scaling and decarburization without the use of special atmospheres . . . even from bath to quench since a thin protective layer covers the metal. Partial immersion of the work also allows selective heating.

With all of this, initial *costs*, operating costs and maintenance costs are low. Long pot life means less down time; high thermal efficiency means low operating expense. Mechanization saves labor costs, increases production.

Why not check with your *Process Chemicals* salesman and learn of the "engineered advantages" of Cyanamid's highest quality heat treating salts—or drop us a line. Then, put your heat treating, case hardening and carburization jobs into a bath filled with Cyanamid Salts, settle back and enjoy the satisfaction of a job well done.

**AEROCARB® – Carburizing Compounds**
**AEROCASE®—Case Hardening Compounds**
**AEROHEAT®—Heat Treating Salts**

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## NEWS TO HEAT TREATERS

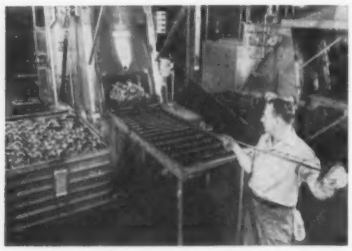
*(Continued from page 20)*

agonal furnace (115 or 230 volts, chamber 6⅝" dia. x 11½" deep), stainless steel pot (6½" dia. x 7½" deep) with cover and convenient lifting handle, and thermocouple in protection tube. Optional maximum-use accessories include a refractory ladle, refractory chamber liner, and insulated cover.

***For further information circle No. 4***

### FAST INITIAL QUENCH

At Ridge Tool Company, Elyria, Ohio, a basket of workholders for "Ridgid" 65R pipe threaders is shown here being loaded into a Lindberg #3 controlled atmosphere furnace for carbonitriding to .005-inch case depth. After soaking for 30 minutes at 1400°F, the workholders are quenched in Gulf Super-Quench at 180°-200°F for 25 minutes.



According to Gulf Oil Corp., the high initial quenching speed of this oil in the critical hardening range and the slow cooling rate in the distortion range enable the heat treat department at Ridge Tool to obtain superficial hardness readings of 15N90 and to hold the 3 3/16" tap hole to within .003.

***For further information circle No. 5***

### CARBURIZING FURNACE

A new dew point-control carburizing furnace has been developed for heat treating truck components for The White Motor Company at its Cleveland manufacturing plant.

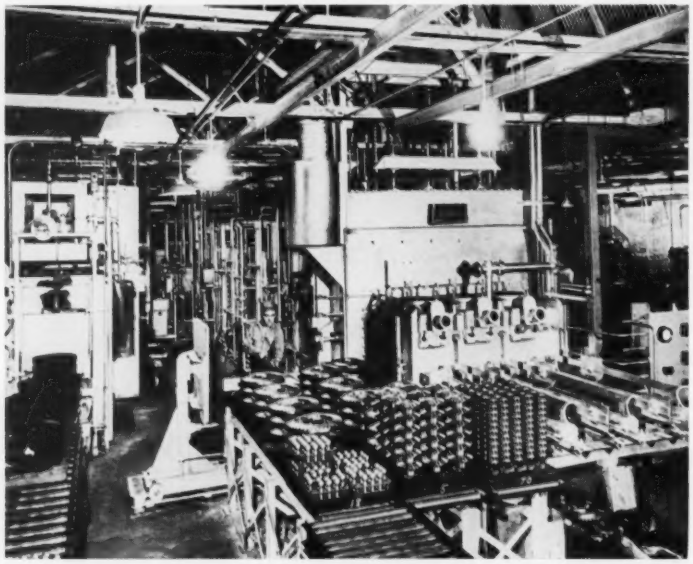
The 57-foot-long continuous pusher-type furnace, built by Surface Combustion Corporation, Toledo, Ohio, automatically carburizes 700 net pounds per hour of ring gears, spider gears, ball studs, kingpins, and the heavy cased parts required in White's single and multiple speed axles and other vital assemblies.

Exact control of dewpoint and temperature through five different zones results in uniformly high quality of case depth and hardness of all truck parts treated. High carbon potential of the first zone is reduced in subsequent zones for accurate diffusion of carbon to the required levels.

The new gas carburizing furnace is alleged to be the first to use an externally-movable slot door for manual extraction of individual gears for press quenching. The furnace also is equipped for automatic conventional oil quenching, martempering, and air quenching. The carburizing cycle from loading to cooling, totals 19 hours; after treating, the surface is file hard, there is no retained austenite, and the parts consistently meet quenched hardness of Rockwell C-61-64 and final hardness of Rockwell C-59-63.

Parts to be heat treated in the carburizing furnace are loaded on trays which automatically carry them through successive control zones. Temperatures range from 1700° to 1550° and dewpoint from —5° to +25°F in the five zones. The furnace also has controls for safety, fire hazard, and explosion protection.

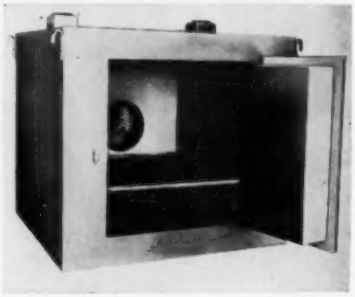
***For further information circle No. 6***



### TRENT OVEN

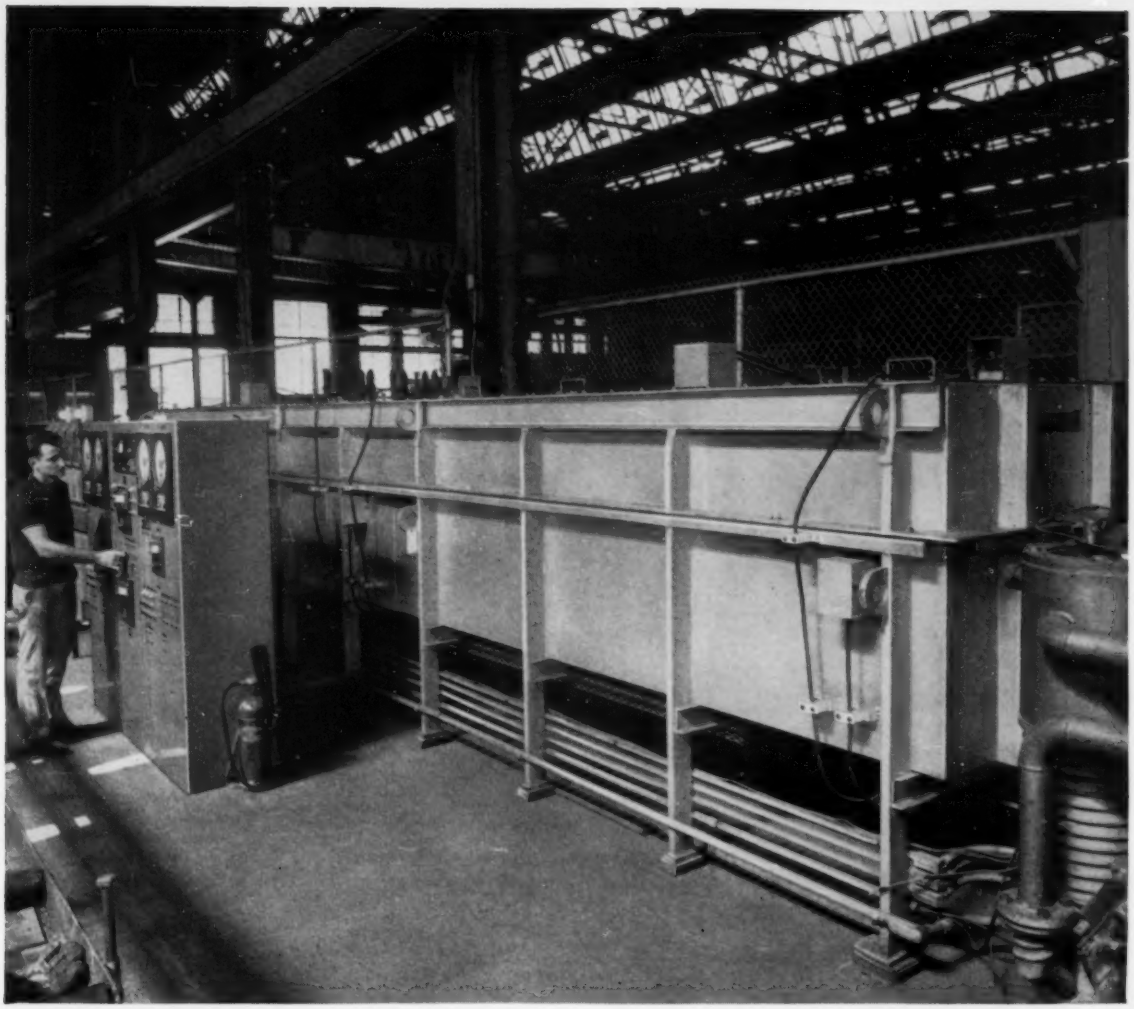
Trent, Inc., Philadelphia, is producing a new basic oven for controlled heating processes up to 650° F. with all extras optional. It is designed to meet the demand for "custom-made" heating without the expense of extra equipment which may be unproductive for the small shop.

The basic oven, designated "COF", has the company's 'Folded-and-Formed' heating elements, 3" glass wool insulation, steel casings, direct drive fan, a single hinged door with explosion release latch, and one shelf. It is available in four sizes and three voltages, with or without forced air circulation.



***For further information circle No. 7***

*(Continued on page 26)*



# Wrought Inconel outlasts low alloy 2 to 1 in muffle for vacuum annealing furnace

**High temperature strength, corrosion resistance and weldability make Inconel alloy ideal for chambers of vacuum heat treating equipment.**

The muffle in the furnace shown is Inconel* nickel-chromium alloy. Its predecessor was a low alloy material. The Inconel alloy muffle had already lasted twice as long as its predecessor and, from its condition, it is expected to last much longer still, according to Bridgeport Brass Company engineers.

**Conditions that make comparison significant are typical and severe**

In this muffle, the Bridgeport Brass Company anneals zirconium tubing at 1800°F (top) and in an extremely low vacuum. The muffle is 10 inches O.D. It is heated for about 25 feet of its 31-foot length. All welds are X-ray quality. The furnace was designed by High Vacuum Equipment Corp., Hingham, Mass.

As you can well understand, vacuum and temperature differences severely stress metal and welds. Any slack off in stress-rupture performance or any corrosion of the metal, or any porosity or inclusion in the weld could lead to spoilage of the tubing which is produced to very high specifications because of its use in nuclear reactor components.

The ability of Inconel alloy to stand up under these conditions... typical of vacuum heat treating... suggests one reason why Inconel alloy is widely used in similar applications. Its weldability and fabricability are equally important.

Would you like more information on the performance of Inconel alloy in vacuum and other heat treating applications? If so, just let us know.

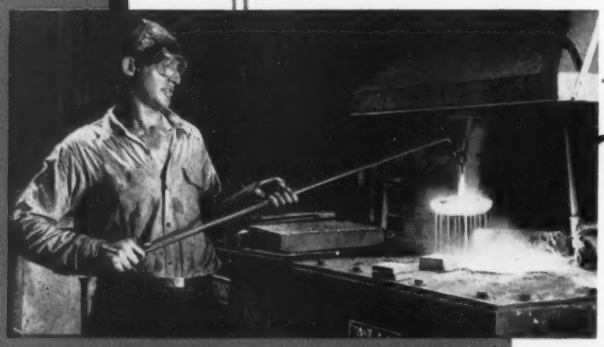
**The International Nickel Company, Inc.**

67 Wall Street INCO New York 5, N.Y.

*Registered trademark

INCO NICKEL ALLOYS

# Bear in mind– it takes SKILL and EXPERIENCE to Heat Treat Metals . . . Your Commercial Heat Treater provides BOTH



It takes more than equipment, no matter how modern, to perform the complex heat treating processes required today to achieve the property specifications of many metals.

Without the proper combination of operational skill and technical knowledge developed by years of experience, even the most mechanical, up to date equipment can become a menace to your product and a destroyer of your business.

Today the commercial heat treating industry has definitely established its position as the source of skilled, experienced heat treating for all types of metals. Whatever your heat treating problem, always consult your commercial heat treater FIRST.

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Write for the booklet "Heat Treating—Should You Do It Yourself"

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### CONNECTICUT

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**Stanley P. Rockwell Co.**
296 Homestead Ave., Hartford 12
**Ireland Heat Treating Co.**
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**Perfection Tool & Metal Heat Treating Co.**
1756 West Hubbard St., Chicago 22
**Fred A. Snow Co.**
1942 West Kinzie St., Chicago 22
**American Steel Treating Co.**
P. O. Box 396, Crystal Lake
**Lindberg Steel Treating Co.**
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**Eklund Metal Treating, Inc.**
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**Ipsenlab of Rockford, Inc.**
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**New England Metallurgical Corp.**
475 Dorchester Ave., South Boston 27
**Springfield Heat Treating Corp.**
99 Margaret Street, Springfield
**Greenman Steel Treating Co.**
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### MICHIGAN

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**Bosworth Steel Treating Co.**
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**Commercial Steel Treating Corp.**
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**Commonwealth Industries, Inc.**
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**Royal Oak Heat Treat, Inc.**
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**American Metal Processing Co.**
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### MINNESOTA

**Metallurgical, Inc.**
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### MISSOURI

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**Lindberg Steel Treating Co.**
650 East Taylor Ave., St. Louis 15
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**American Metal Treatment Co.**
Spring and Lafayette Sts., Elizabeth
**Benedict-Miller, Inc.**
Marin Ave. & Orient Way, Lyndhurst
**Bennett Heat Treating Co., Inc.**
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**Temperature Processing Co., Inc.**
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**Fred Heinzelman & Sons, Inc.**
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**Alfred Heller Heat Treating Co., Inc.**
391 Pearl St., New York 38
**Lindberg Steel Treating Co.**
620 Buffalo Road, Rochester 11
**Rochester Steel Treating Works**
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**General Heat Treating Corporation**
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**Syracuse Heat Treating Corp.**
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**Ferrotherm Co.**
1861 E. 65th St., Cleveland 3
**Lakeside Steel Improvement Co.**
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**George H. Porter Steel Treating Co.**
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**Reliable Metallurgical Service, Inc.**
3827 Lakeside Ave., Cleveland 14
**Winton Heat Treating Co.**
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**Dayton Forging & Heat Treating Co.**
2323 East First St., Dayton 3
**Ohio Heat Treating Co.**
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**J. W. Rex Co.**
834 West 3rd St., Lansdale
**Lorenz & Son**
1351 N. Front St., Philadelphia 22
**Metlab Company**
1000 E. Mermaid Lane, Philadelphia 18
**Pittsburgh Commercial Heat Treating Co.**
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**Pittsburgh Metal Processing Co., Inc.**
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**Superior Heat Treating Co., Inc.**
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**United Heat Treating Company**
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**Cook Heat Treating Co., of Texas**
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**Houston Heat Treating Company, Inc.**
2100 Quitman Street, Houston 26
**Lone Star Heat Treating Corp.**
5212 Clinton Dr., Houston 20

### WISCONSIN

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**Metal Treating, Inc.**
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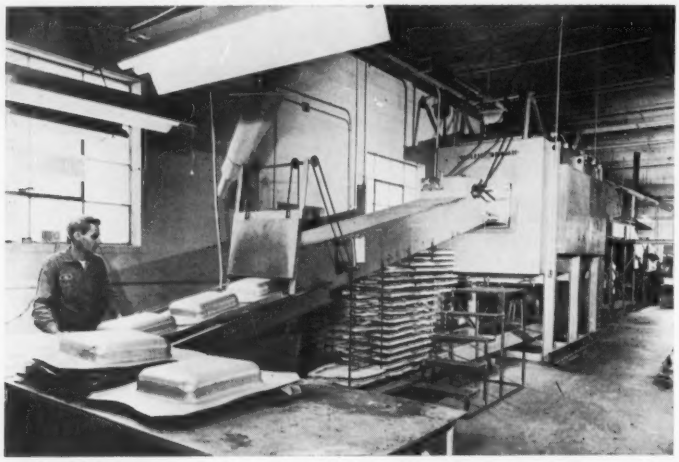
MTI MASTER CRAFTSMEN METAL TREATING INSTITUTE

## NEWS TO HEAT TREATERS

*(Continued from page 22)*

### BRIGHT BRAZING AND HEAT TREATING STAINLESS STEEL AT 2100°F.

What is believed to be the largest belt conveyor hump-type hydrogen controlled atmosphere furnace



manufactured for commercial purposes—without metal muffles—is being used by Hi-Temp Inc., Northlake, Illinois, for high production bright annealing, brazing and atmosphere quenching of stainless steel dies.

Large stainless steel dies are bright hardened with an absolute minimum of distortion by this hump-type, 25-inch mesh-belt electric furnace designed and built by General Electric's Industrial Heating Department.

The furnace is 71 feet long and uses a special high purity almina brick that maintains a continuous dew point of -60 and produces bright, oxide-free results. "With the new furnace and its larger conveyor belt, we can bright anneal 18-8 stainless steel kitchen sinks prior to trimming after the initial draw. Precision aircraft and missile parts made of 416, 420 and 440 stainless are also brazed in the furnace while maintaining tolerances of 0.0005," according to E. J. McCrink, president of Hi-Temp.

Many precision electronic components, made of a combination of 18-8 stainless steel and carbon steel, are bright copper brazed without flux in the controlled hydrogen atmosphere, according to Hi-Temp engineers.

Two-zone control in the new hump-type furnace helps achieve maximum production by maintaining a controlled temperature at the exit end of the furnace. Cold materials entering the first zone do not affect the controlled temperature in the second zone, according to General Electric engineers.

Contamination of the hydrogen atmosphere is minimized by a long and inclined "purge" chamber that angles up to the heating chamber entrance. Protective atmosphere consumption inside the elevated heating chamber is kept at a low level because of the hump-type design. The new electric furnace—without metal muffles—is rated 2100°F at 195 kw.

***For further information circle No. 8***

"THIS IS FOR SUB-ZERO METAL TREATMENT, SAM!... IT'S NOT A DEEP FREEZE!"

### NEW PLATING PROCESS BY HEAT TREATING

A new heat-plating process now used by Metallurgical Consultants, Inc., Maywood, Calif., is said to be so effective that it transforms a thin layer of plating substance into an integrated part of the base metal —thus eliminating any possibility of peeling, chipping, flaking, or lifting. The process is named Pyro-Plate.

It has been applied to virtually all ferrous and copper materials and is said to cost less than conventional plating methods.

Invented by Hoyt H. Todd, a veteran metallurgical engineer, it involves the initial application of a paint or paste-type coating which contains powdered nickel or cobalt alloys. This can be accomplished with an ordinary paint brush,

*(Continued on page 29)*

# "PARK-KASE GIVES US TOP QUALITY CRAWLER TRACTOR PARTS... CUTS HEAT TREAT COSTS 50%"

William J. Blazek, President, Evans Reamer and Machine Company, a manufacturing division of Lempco Automotive, Inc., Cleveland, says, "QUALITY must be the watchword around here because Lempco's replacement parts go into practically every type and make of crawler tractor. These parts have got to be good to meet the challenging requirements of this great tractor industry.

"On track bushings, for example, correct heat treatment is essential to the quality of the product—and costs must be in line.

"After a great deal of investigation, we decided that the high quality of Lempco's bushing could best be achieved effectively through the use of salt bath heat treatment. We selected Park-Kase No. 2 Energizer for the salt bath operation. It has never let us down.

"More than 19 different-sized track bushings—all with different wall thicknesses—all made from low carbon steel—are carburized at 1750 deg. F. in Park-Kase. There is also the economy of a direct quench in an 8% brine solution maintained at 70 deg. F. by refrigeration. Bushings are fully case-hardened to the required accepted standards. Case depths up to 0.110 in., depending upon wall thicknesses involved, are readily obtained in our salt bath heat treatment.

"We have achieved the top quality in these replacement parts that we must have. We have done this at a saving in cost of 50% over the previous heat treat methods. In fact, salt consumption and costs are lower than even the pre-installation estimates.

"To make a long story short, we must have quality and economy in this operation. Park Chemical Company more than satisfies our requirements."

For complete data on Park-Kase No. 2 Energizer write for technical bulletin A-1. Park Chemical produces a complete line of heat treating materials and would be happy to help you work out a solution to your heat treating problems without obligation. Call or write today.

Evans Reamer and Machine Company uses Park-Kase Energizer #2 to case-harden track bushings up to 0.110" case depth. Inspecting track bushings that have been case hardened are (l. to r.): from Evans: *Lynn M. Leslie, Production Manager; LeRoy L. Johnson, Superintendent; William J. Blazek, President;* from Park Chemical's Cincinnati Office, *James F. Hetz.*

Park

Woodside Rapid Carburizers (Non-Burning—Charcoal–Coke–Specification) ● Park-Kase Liquid Carburizers ● Quenching and Tempering Oils ● Cyanide Mixtures ● Neutral Salt Baths ● High Speed Steel Hardening Salts ● Iso-Thermal Quenching and Tempering Salts ● Protective Coatings (No-Carb—No-Kase—No-Scale—No-Tride) ● Carbon Products (Charcoal–Crushed Coke-Pitch Coke–Lead Pot Carbon) ● Kold Grip Polishing Wheel Cement ● Par-Kem Metal Cleaners ● Cutting and Grinding Compounds (Kem-Cut—Kem-Grind—Blue Ice)

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# M.T.I. *Activities*

### WASHINGTON ACTIVITIES

Recently the Executive Secretary's office of the Metal Treating Institute, represented by the Executive Secretary, C. E. Herington and his Assistant, H. R. Herington, attended several important meetings in Washington, D. C., and a report of these activities follows:

In May an application for membership in the Society of Business Magazine Editors for Herbert R. Herington, Managing Editor of *Metal Treating,* had been sent in, and an invitation to attend the Society's two-day meeting in Washington was received in June. Word has since been received that the application has been reviewed, and H. R. Herington has been accepted into full membership.

The highlight of the SBME meetings was a conference with President Eisenhower in the White House. He received the eighty editors in the Press Room and talked to them about what he described as a very vital problem of our times —"our growing pension society." (Editor's Note: For a fuller account of this meeting see the article below entitled "Our Pension Society"). Other meetings and workshop sessions were attended, and much valuable information gained through the Society's efforts to promote the welfare and value of business magazines.

While in Washington, the Executive Secretary also called upon Mr. N. A. Olsen, Director of the Metalworking Equipment Division of the U. S. Department of Commerce and Mr. Robert E. Fleming, Executive Vice President of the Industrial Heating Equipment Association. During both visits, the subject of a new census of industrial heating furnace equipment which is in the process of being taken was discussed, and the interest and cooperation of the MTI in working closely with them in such a project was promised. A roster of the membership of the MTI was given to Mr. Olsen who expressed his desire to communicate with the members to gain information which would be of value to him in regard to some projects his Metalworking Division is now working upon.

---

### OUR PENSION SOCIETY

When President Eisenhower talked recently to the editorial staff of *Metal Treating* who were among the group of business magazine editors attending the Society of Business Magazine Editors press conference with the President at the White House, he got to reminiscing, and we thought that our readers might find something useful in some of our President's memories:

"When I was a boy, it was thought we could live our lives on a little piece of ground in the West, and the older folks—grandfather and grandmother—could live in the same home, after their days of hard work were ended. That's the way we took care of ourselves and our older people.

"Today, through the changes in our industrial system, we as a people have become dependent for old age security more and more upon pensions, insurance policies, savings bonds, and savings accounts. These are the people that are particularly hurt by depreciation of the dollar . . . A man who puts away his savings to be used 40 years from now can receive some startling lessons over that 40-year period.

"My wife and I decided, in 1916, to get married. Since I, like all other Second Lieutenants, was always overdrawn at the bank, I decided that I ought to show a little more sense of responsibility. So I began to buy a small insurance policy . . . Thirty years later the company came around to pay off. It was so small (in terms of today's dollars) that I would have been ashamed to ask my wife to exist on it for six months.

"Today think of the man at the lathe, the drill press, who is earning money which he is putting away in his pension with his company or into an insurance policy. If we cannot today assure him that 40 years from now he is going to be able to have a living left, then I say, sooner or later, he will quit buying insurance policies, he will not have confidence in a Government bond, and he will not think much of his pension."

This was the same talk at which the President created an uproar by suggesting that the Government ought to get its debt management in order, as he formally proposed to Congress later, even if that meant paying higher interest rates.

---

### INDUSTRIAL APPOINTMENT

Ralph E. Mueller, 39, has been named Director of Customer Relations by Metallurgical, Inc., Minneapolis, commercial heat treater serving industry and the armed forces. Mueller was formerly Assistant Director of the Aircraft & Ordnance Division of National Presto, Eau Claire, Wis.

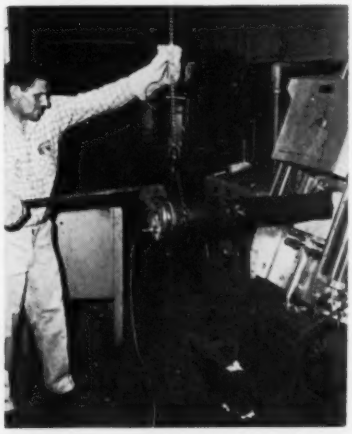
## NEWS TO HEAT TREATERS

*(Continued from page 26)*

squeeze bottle, spray gun, spatula, flame-spray gun, or dip-coating tank. Deposition surfaces should be clean, but require no special preparation, and may be masked in areas where plating is unwanted.

Next, organic coating constituents are vaporized and metal powder particles are fused into deposition materials by heat treating the latter in a furnace with inert atmosphere.

The plating compounds may be applied with almost any desired thickness; they adhere readily, dry quickly, and permit easy plating of such things as tube and valve interiors which cannot be electroplated. Varying metal powder contents of the compounds make it possible to obtain plating with special properties such as high corrosion, oxidation, or abrasion resistance.



Machine cutting tools such as drills and taps, chain saw teeth, oil tool slips, farm implements, rotary and blade knives, marine hardware, high tensile bolts, and pole line components are among the items that have been plated by means of the new process.

***For further information circle No. 9***

## HUMPBACK FURNACE

A new humpback furnace recently put in operation at National Heat Treating Co., Inc., Inglewood, Calif., is believed to be one of the more efficient high-temperature brazing facilities in current operation.

*(Continued on page 32)*


VACUUM

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Bulletin 4000.1 fully describing the KINNEY PW Packaged Pumping Systems is yours FREE. Mail the coupon today.

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## On The Formation Of Martensite

By E. J. PAVESIC

When *steel* is heated to the hardening temperature, it undergoes a change in microstructure. At the beginning of the heating operation, the steel consists of ferrite and carbide constituents (pearlite, spheroidized carbides or other intermediate constituents). At the hardening temperature, the steel consists of austenite which is a solid solution of carbon in gamma iron. Depending on the carbon and alloy content of the steel, the hardening temperature, time at heat and the prior microstructure, a part or all of the carbon or carbides will dissolve in the austenite.

On quenching, the austenite transforms and the hardness of its transformation products will depend on the rate of cooling. To produce complete hardening, the actual rate of cooling of the quenched piece should be equal to or greater than the critical cooling rate of the steel. If the cooling rate in quenching is greater than the critical cooling rate, the austenite transforms into the hard, brittle constituent martensite, the hardness of which will be dependent on the amount of carbon dissolved in the austenite initially.

The temperature at which the austenite to martensite transformation begins is termed the Ms temperature (for martensite start point) and the temperature at which this transformation ends is termed the Mf temperature (for martensite finish point). The carbon and alloy contents and the austenitizing temperature govern the temperature range of martensite formation. Listed below are the Ms and Mf temperatures for a number of carbon and alloy steels.

| *AISI-SAE Grade* | *Ms °F* | *Mf °F* |
|---|---|---|
| * 1008 | 925 | 835 |
| * 1019 | 825 | 730 |
| * 1050 | 615 | 475 |
| 1065 | 525 | 300 |
| 1090 | 420 | 180 |
| 4130 | 710 | 550 |
| 4140 | 640 | 425 |
| 8630 | 695 | 525 |
| 52100 (1550°F quench) | 480 | 230 |
| 52100 (1950°F quench) | 295 | 40 |

* Ms and Mf points estimated—Mf values are for 90 per cent martensite; these steels only.

From the above, it is quite evident that the carbon content of the steel is one of the most important variables governing the temperature at which the austenite to martensite transformation begins.

The formation of martensite from austenite is solely dependent upon cooling, and any interruption of cooling between the Ms and Mf temperatures will also interrupt the formation of martensite. Extended interruptions of cooling between the Ms and Mf temperatures will cause the untransformed austenite to transform isothermally to extremely fine intermediate products, such as, Bainite. AISI-SAE 4140, for example, austenitized at 1550°F and quenched in 120°F oil will begin to form martensite at 640°F; at about 575°F, 50 per cent martensite will have formed; at about 525°F, 90 per cent martensite will have formed, and at 425°F, 100 per cent martensite will have formed. Since the carbon range of this steel is 0.38 to 0.43 per cent, the fully martensitic hardness would be about 59 to 62 Rockwell C. If instead of quenching into oil at 120°F, the same steel was quenched into a bath maintained at 575°F and held for one hour, the microstructure would consist of 50 per cent martensite and 50 per cent Bainite having a hardness of about 52 Rockwell C.

The sensitivity of steels to cracking in heat treatment is related to their carbon content and hardenability (other properties being equal); and because the Ms temperature is so greatly affected by carbon content, it directly affects the propensity of steels to cracking. For example, the Ms temperature is lowered from 925°F for an AISI-SAE 1008 steel to 420°F for an AISI-SAE 1090 steel.

The low carbon steels, those having less than 0.25 to 0.35 per cent carbon, are virtually impossible to crack probably because of their high Ms temperatures and their relative plasticity in the temperature range of martensite formation. In addition, the martensite formed during quenching is tempered during subsequent cooling to below the Mf temperature, thus providing a certain amount of stress relief.

Steels over 0.35 per cent carbon are more prone to cracking in heat treatment and the propensity increases with increasing carbon and hardenability. In reviewing the Ms temperatures for 44 widely used carbon and alloy constructional steels, 16 steels with carbon contents of 0.35 per cent and lower, exhibited Ms temperatures between 640° to 925°F, while 28 steels of 0.36 per cent and higher carbon exhibited Ms temperatures between 415° to 650°F. Fig. 1 is a plot of the relationship between the carbon

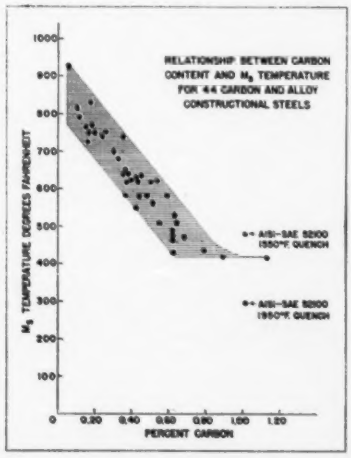
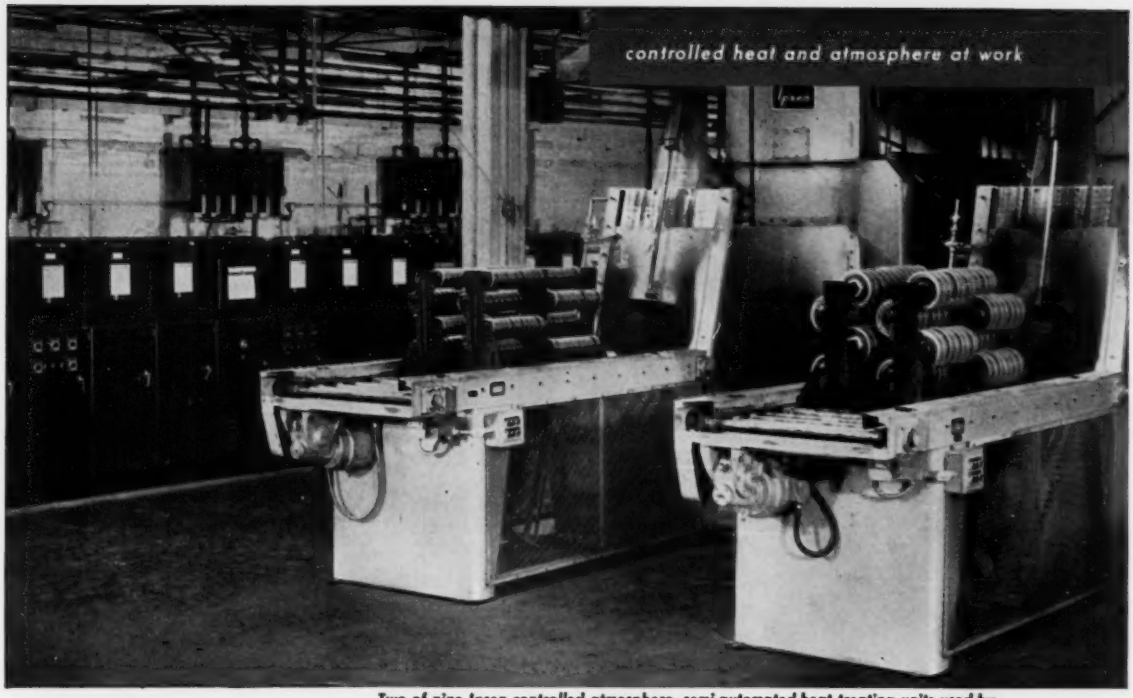

RELATIONSHIP BETWEEN CARBON CONTENT AND Ms TEMPERATURE FOR 44 CARBON AND ALLOY CONSTRUCTIONAL STEELS
Ms TEMPERATURE DEGREES FAHRENHEIT
PERCENT CARBON
AISI-SAE 52100 1550°F QUENCH
AISI-SAE 52100 1950°F QUENCH

Figure 1

*(Continued on page 32)*




*Two of nine Ipsen controlled atmosphere, semi-automated heat treating units used by Fuller Manufacturing Company (a subsidiary of Eaton Manufacturing Company), Kalamazoo, Michigan*

# "We've increased production with our seven Ipsen Furnaces."

*Fuller Manufacturing Company*
*—a subsidiary of Eaton Manufacturing Company*

*George M. Travers is Chief Metallurgist of Fuller Manufacturing Company (a subsidiary of Eaton Manufacturing Company), Kalamazoo, Michigan, a well-known producer of heavy duty transmissions for manufacturers of trucks and tractors. In the following interview, Mr. Travers tells why he is pleased with his Ipsen equipment.*

**Q.** During the last eight years you have bought a number of Ipsen controlled atmosphere, semi-automated heat treating units, and related equipment, for carburizing applications. What type of work do you normally carburize in this equipment?

**A.** We use your equipment mainly for deep case carburizing of heavy section gears and countershafts for our "Road Ranger" transmissions. We also carbonitride power take-off gears, shifting forks, and washers where we need file hardnesses. Our first Ipsen furnace and generator were installed in 1951. In 1955, we added three large, double chamber, semi-automated units and a draw furnace. Then again the following year, we installed three more similar units and another draw furnace. We also use Ipsen atmosphere generators and Dewtronik equipment.

**Q.** Does your Ipsen carburizing equipment replace other types of equipment?

**A.** It supplements large, multiple-row furnaces used for routine carburizing. The Ipsen units give us greater latitude in choice of cycles, carbon concentrations, and case depth characteristics.

**Q.** Have you been able to increase production with your Ipsen equipment?

**A.** Yes . . if you mean increased production per square foot of floor area, or decreased over-all time of treatment. Also, we find that when it is necessary to increase or decrease heating or holding time for different parts, we can do it much easier and faster in the Ipsen forced convection equipment.

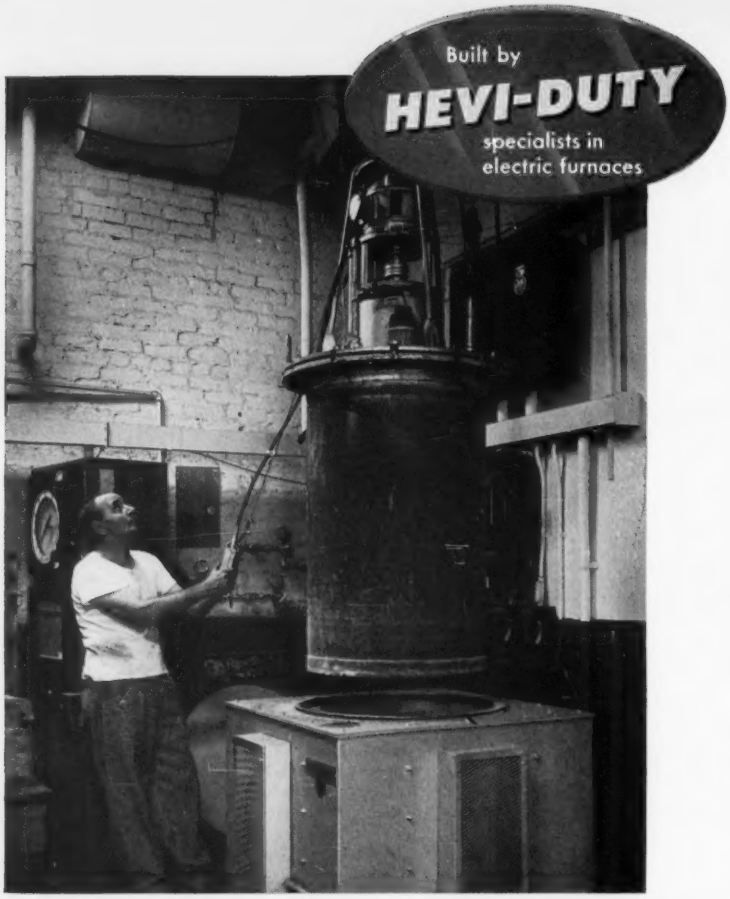
**Q.** What about your maintenance costs?

**A.** Your furnaces have a minimum of alloyed parts subjected to heating and carburizing conditions, and the life of conveying trays has been good. The vertical ceramic heating tubes are easy to replace. And they do not bend or sag during operation. Maintenance cost, per pound of work treated, for our Ipsen equipment is comparable . . perhaps lower than for our bigger furnaces. Your equipment is easier to maintain. Another advantage is that with several smaller Ipsen furnaces, we can shut down one for maintenance without completely curtailing all production.

*A brochure discussing the type of Ipsen equipment used by Fuller is available. Ask for your copy.*

AUTOMATIC Ipsen HEAT TREATING UNITS

**IPSEN INDUSTRIES, INC. • 733 S. MAIN STREET • ROCKFORD, ILLINOIS**




## Two Retorts Double the Furnace Output at Cannon Electric Company

Cannon Electric Company, Los Angeles, age hardens as many as 150,000 beryllium copper springs in a single retort load, while a second retort slow cools with the springs protected by a special atmosphere. This produces bright, scale-free parts, yet permits constant use of the furnace. The Company chose a Hevi-Duty "Versa-Duty" pit furnace to do this double duty for several reasons:

They like its excellent uniformity. Temperature variations are held within plus or minus 10° F. despite the dense load. They like the fact that the fan is installed in the cover for easy servicing. They also appreciate its low maintenance. It has required nothing but normal lubrication since it was installed.

For more information on "Versa-Duty" pit furnaces, write for Bulletin 755.

- Heat Processing Furnaces
- Dry Type Transformers
- Constant Current Regulators

HEVI-DUTY ELECTRIC CO.
Milwaukee 1, Wisconsin


### HEAT TREATING HINTS

*(Continued from page 30)*

content and the Ms temperature of these 44 steels. One steel, AISI-SAE 52100 is plotted twice to illustrate the effect of austenitizing temperature on the Ms temperature.

It is not intended to imply here that carbon content and Ms temperature are the sole factors which determine whether or not a given steel will crack in heat treatment. Chemical analysis, hardenability, mass, design, heat treating practice, as well as quenching temperature, quenching medium, etc., and the Mf temperature also exert a profound influence upon the behavior of a given workpiece in heat treatment.

*(To be continued)*

*Source: HEAT TREATING HINTS*
*Lindberg Engineering Company*

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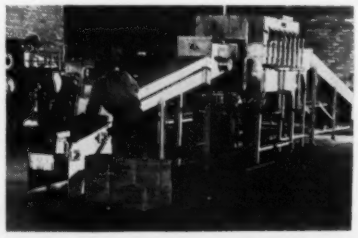
### NEWS TO HEAT TREATERS

*(Continued from page 29)*

Made to National's specifications by Calalloy Co., Los Angeles, it is 47′ long and has a maximum height of 7½′.

Because of the low cost of natural gas in Southern California, it was designed to be gas fired and can maintain close-tolerance temperatures in the 1300° to 2050° F range.

Parts conveyed through the furnace's 60″ long heating chamber can be protected with either dissociated ammonium or dry hydrogen and may be as large as 7″ high, 12″ wide, and 3′ long.



Operating speeds for the unit's belt-type conveyor system may be varied from ¼″ to 2′ per minute, of which the latter is said to be the highest speed in current use in Southern California.

The new furnace is the twenty-sixth gas-fired heater that has been put to work by National, a specialist in the heat treatment of ferrous metals as well as in copper and silver brazing.

Other facilities employed by the company include a Hevi-Duty electric furnace, which is used where inert gas treatments are specified, and a pair of induction heating machines.

*For further information circle No. 10*

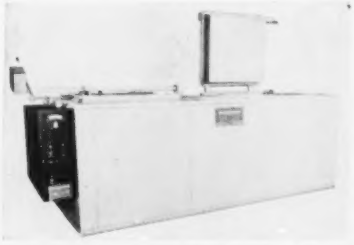
### AJAX SALES MANAGER

Appointment of O. M. Haseltine as sales manager of Ajax Electric Company, salt bath furnace manufacturers, has been announced by President Leon B. Rosseau.

Mr. Haseltine who now makes his headquarters at the Ajax general offices in Philadelphia, Pa. had served as Ajax sales engineer in the Chicago and Midwest territory.

### EXTRUSION DIE HEATER

Grieve-Hendry Co., Inc., Chicago industrial oven manufacturer, announces the development of a new extrusion die heater with a convenient top side loading height of just 37".



Another operational convenience offered is counterweighted doors.

*For further information circle No. 11*

*(Continued on page 36)*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***There's a Wilson "Rockwell" instrument to do the job***

Wilson "Rockwell" Hardness Testers can help make your products better, stronger, longer lasting. They give reliable results on the production line, in laboratories, in tool rooms, and in inspection departments. They're as easy to use as a center punch, as durable as a machine tool, as sensitive and accurate as a precision balance. That's why Wilson "Rockwell" is recognized as the world's standard of hardness testing accuracy.

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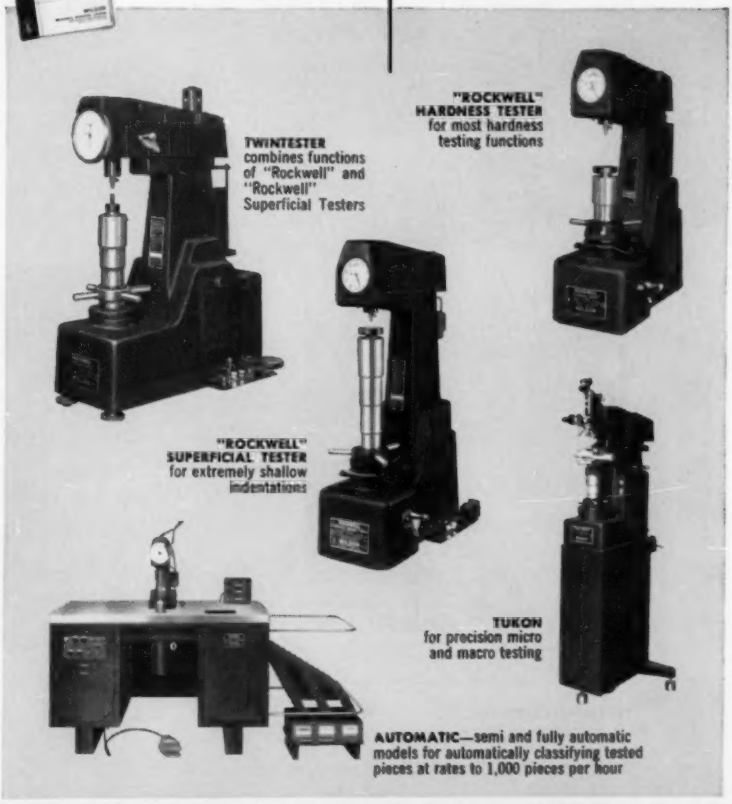
A perfect diamond penetrator is essential to accurate testing. Only flawless diamonds are used with Wilson "Brale" penetrators. Each diamond is cut to an exact shape. Microscopic inspection and a comparator check of each diamond—one by one—assure you of accurate hardness testing every time.

*Write* for Catalog RT-58. It gives complete details on the full line of Wilson hardness testing equipment.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combines functions of "Rockwell" and "Rockwell" Superficial Testers
"ROCKWELL" HARDNESS TESTER
for most hardness testing functions
"ROCKWELL" SUPERFICIAL TESTER
for extremely shallow indentations
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AUTOMATIC—semi and fully automatic models for automatically classifying tested pieces at rates to 1,000 pieces per hour

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## CERAMIC COATINGS

*(Continued from page 3)*

high temperature operation and will protect the basic metal. In bending or flexing, the coatings will stand deflection somewhat beyond the elastic limit of the metal.

The coatings' resistance to shock will be most affected by the amount of inert materials in the composition. Usually the more inert the material, the less the impact resistance; but in some cases, both impact resistance and thermal shock resistance are improved.

High temperature coatings must pass these tests without spalling or other deterioration:

1) Heat 45 minutes to 100° to 200°F hotter than maximum expected operating temperature, followed by 15 minutes quenching in air. Repeated nine times daily followed by 15 hours soak at temperature. This test is continued for a total of 200 hours.

2) Coated parts are heated to 1700°F and water quenched through ten cycles.

Samples must have sufficient coating to withstand this standard thermal shock test for 50 hours after they have been struck with a ball peen hammer and bent to a 90 degree arc. The prime criteria for excellence of ceramic coatings under the thermal shock from mechanical strain is a thin coating. Coatings are made under ten thousandths of an inch, while the majority are only one or two thousandths of an inch.

***Fig. 4—Sandblasting takes off any scale left by acid; also etches surfaces so they will take coating better. No. 45-mess flint shot is forced through hose at 40 psi, which is not high enough to warp or distort the parts.***

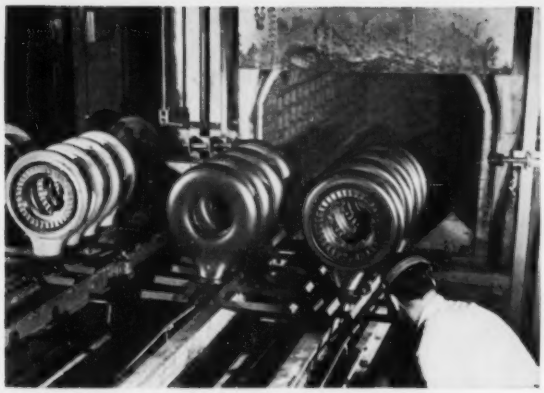

*Fig. 5—Firing is the final operation, done in muffled box furnace at 1875°F for 35 minutes. Furnace is oil-fired and closely controlled to prevent spalling or jumping of ceramic coat before it is completely solidified.*

Ceramic coatings also have excellent abrasion resistance. They tend to have values of 5 to 5½ on Moh's scale of mineral hardness, and this means they are considerably harder than brass, aluminum, copper and many forms of steel and steel alloys. Some coatings have the hardness of topaz.

Fatigue tests of coated and uncoated samples on the standard Krouse machine at 1700°F resulted in average fatigue life of more than one million cycles for the coated samples. Under the same conditions, uncoated samples failed after 160,000 cycles. Similar results were obtained at room temperature.

The coatings also can increase lap-weld endurance life. Laboratory tests have shown that five uncoated lap-weld samples endured 686,000 cycles while similar uncoated samples, heat treated ten minutes at 1750°F lasted 304,000 samples. Samples processed with ceramic coating attained a life of 6,000,000 cycles.

A relatively little-known quality of the coatings is their value as electrical insulators. Voltage breakdowns per thousandths of an inch of thickness can vary from 0 to 1000, depending on formulation. Normally, coatings high in lead content have higher insulating value. The thicker coatings usually offer greater dielectric strength. In cases where the ceramics have a high melting point, a thinner coating may be used.

Ceramic coatings will also act as a fluxing agent and permit arc and gas welding to the coating. When weldment is properly made, the coating remains intact almost to the edge of the weld area. However, on alloys containing 20% or more nickel, the coating should generally be removed prior to welding.

Aside from aircraft and rocket components, some of the new uses for ceramic materials tested and approved in the past year include nichrome heating elements of all sizes, soldering fixtures, heat treating furnace carriers, conveyor belts, industrial furnace tubes and accessories, refinery tubes and parts, retorts and tanks, brazing furnace fixtures, expansion joints, melting pots and ovens. • • •


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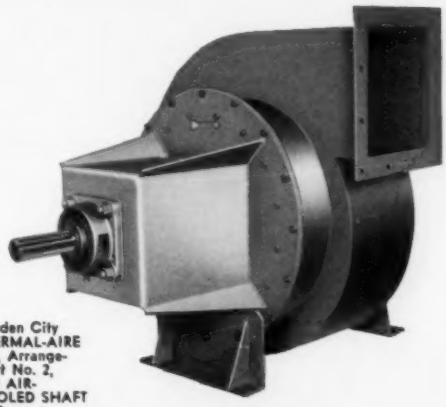
Garden City's new RF THERMAL-AIRE radial blade fans are durable, trouble-free, efficient. Modern, simplified in design, they are "tailored" for various temperatures to precisely meet your needs.



Garden City THERMAL-AIRE Fan, Arrangement No. 2, with AIR-COOLED SHAFT for temperatures to 1700°F.

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*ESTABLISHED 1879*

Representatives in leading cities
**801 North Eighth St., Dept. T, Niles, Michigan**

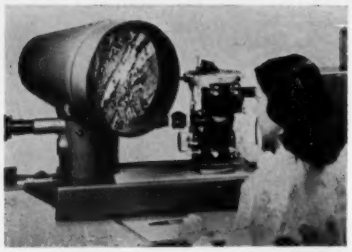
## NEWS TO HEAT TREATERS

*(Continued from page 33)*

### LEITZ MICRO-METALLOGRAPH

A 30" projection screen is featured in the new Leitz Micro-Metallograph, developed under the direction of Dr. Hein Claussen at Leitz in Wetzler, Germany, and introduced at the National Metal Exposition in Cleveland.

The Le Chatelier type instrument permits precise details of metallurgical specimens to be viewed simultaneously on the screen as well as through a binocular observation tube.



A powerful Xenon lamp provides illumination to permit observation in a normally lighted room. A prealigned 5" x 7" camera allows quick and simple photomicrography of specimens. If desired, a Polaroid-Land 4" x 5" camera back may be used.

***For further information circle No. 12***

### WELDING WITH ELECTRONS

High Vacuum Equipment Corporation, Hingham, Mass., manufacturer of vacuum processing equipment, has introduced a welder using the concentrated energy of a focused beam of high velocity electrons. These new Beamatron® welders will be employed to weld high-temperature reactive metals and super-alloys in nuclear, electronic, and missile hardware. They

are said to be capable of welding metals ranging from aluminum to zirconium; thus, it is possible to weld tungsten, tantalum or molybdenum to each other or to other metals satisfactorily.

The company stresses the role vacuum technology plays in modern industry. The use of electrons in welding is possible only in a high vacuum, hence the union of electronic and vacuum techniques to produce a new welding process.

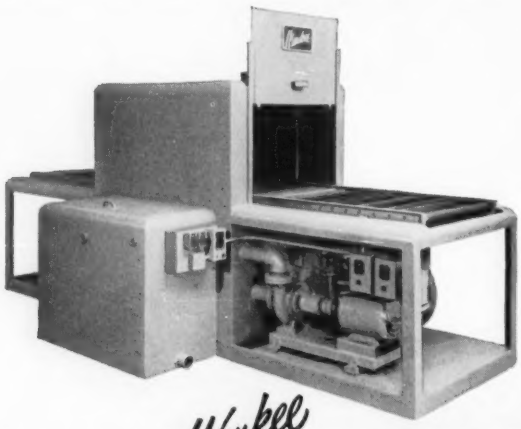
***For further information circle No. 13***

### HIGH STRENGTH ALUMINUM CASTING ALLOY

A new high-purity aluminum alloy which claims unusually high physicals has been developed by Rolle Manufacturing Company, Lansdale, Penna. Called MA-356, the alloy promises new weight saving efficiencies in sand and permanent mold castings for missiles and high performance jet aircraft. A data sheet is available.

By varying the chemical composition of conventional A-356 alloy, Rolle has found an essentially new material, highly responsive to

*(Continued on page 40)*

There's a standard Waukee® WASHER
TO MATCH YOUR CARBONITRIDER OR CARBURIZER!

Whatever the size of your carbonitrider or carburizer, the new Waukee Washer has a standard size to match it. Size range: 24 x 36 x 18 — 24 x 48 x 24 — 30 x 48 x 24 — 36 x 48 x 24.

**COMPLETE — NO "EXTRAS"** — Waukee parts washers come to you complete, ready to locate, connect to utilities, and begin operation. No "extras" to buy and install. Pumps, burners, controls are designed as integral parts of the Waukee Washer. You use your present furnace work-baskets, too.

**FLEXIBILITY** — You gain in flexibility with Waukee Washers. Standard units are available in "in-and-out" feed or straight-through, conveyor type, and in one, two, or three stages with rinse and dry. High-efficiency with gas, electricity, or steam.

**THOROUGH CLEANING** — The smallest Waukee Washer sprays a minimum of *one ton of hot detergent solution through the load each minute.* Solution penetrates work basket from top and bottom, washes away oil and foreign matter from the densest charge. Bull's-eye timer cycles the load for complete washing without guesswork or waste of time.

Complete data in Bulletin 1201 — write for it today.

*Waukee-washed parts are free of cutting and quenching oils, mean clean furnace atmospheres, therefore predictable case depths and cleaner, brighter work.*

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# LETTERS TO THE EDITOR

Dear Editor:

I feel very privileged to have been receiving your interesting publication, *Metal Treating*.

"Case Histories" such as were presented in Mrs. Helen Hoover's article entitled, "Metallurgical Research Develops Improved Products Through Heat Treating" which appeared in your March-April 1959 issue are difficult to come by, and *Metal Treating* has done metallurgists a great service in publishing this article.

If you wish, you have my permission to publish the letter which I wrote directly to Mrs. Hoover, a copy of which follows:

"Dear Mrs. Hoover:

Please accept my congratulations on your excellent article in *Metal Treating* on the 'disk job.' Both your work and your presentation made this very interesting reading. My own interest goes back to pre-war days when cars had clutches and we at Long Mfg. Div. of Borg-Warner were processing and tempering clutch disks from Ingersoll! Our main problem then was grain-size and heat treat prescription. Hardenability hadn't arrived yet then.

Thank you again for very interesting reading."

*Kenneth B. Lloyd*
*Naval Research Laboratory*
*Washington, D. C.*

Gentlemen:

I have been looking through some old issues of your magazine and am pleased with all the good information in them.

I would appreciate it if you would place my name on your mailing list.

*Ray B. Adams*
*Heat Treat Foreman*
*O. E. Szekely & Assoc.*
*Commerce, Georgia*

Gentlemen:

I would appreciate being put on the mailing list to receive the magazine *Metal Treating*.

Watertown Arsenal Laboratories has facilities for heat treating specimens for research and development programs in air, salt, inert atmosphere and vacuum. It is believed that *Metal Treating* will enable the heat treaters to better serve the research and development project engineers.

*D. C. Buffum*
*Chief*
*Metals Research Branch*
*Watertown Arsenal*
*Watertown, Mass.*

Gentlemen:

A copy of "Metal Treating" is regularly received by our Mr. R. H. Solem of Wisconsin Knife Works, Beloit, Wisconsin.

We find that your publication is very interesting and covers many subjects of interest to people dealing with the treating of metals.

We would, therefore, appreciate it very much if a copy of your publication could be received at our Anderson, Indiana, plant.

*Henry E. Cockerill*
*Manager*
*Anderson Knife Division*
*Wisconsin Knife Works*
*Anderson, Ind.*


**General Alloys' TUBULARFORM FIXTURE Used in World's Largest Vertical Drop Bottom Furnace**

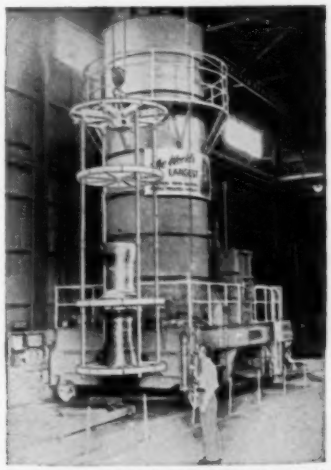

*Photo courtesy Metallurgical, Inc., Minneapolis*

This huge vertical drop bottom furnace, 45 feet high by 9 feet O.D., is used by Metallurgical, Inc. to heat treat missile bodies and rocket motor housings. The *TUBULARFORM* Fixture will support 10,000 pound loads at temperatures up to 1500° F. or 3,000 pounds at 1900° F. The entire loaded fixture is quenched in salt.

General Alloys' *TUBULARFORM* Fixture rated the tough assignment of holding the material to be treated in the furnace because the special *TUBULARFORM* Design can really take punishment.

The fixture, 5 feet in diameter by 16 feet high, is completely cast from General Alloys' X-ite. Uniform section throughout, it has superior strength. It expands and contracts evenly. It won't distort or twist and it gives lowest cost per heat hour.

*TUBULARFORM* Design eliminates corners, edges, and intersections where failures occur. The design gives maximum strength with minimum weight. Payload is increased without sacrificing heat-hour life.

General Alloys' vast experience in the design and manufacture of heat treating fixtures of all kinds . . . for all types of service . . . can be an important asset to you. Branch offices are located throughout the country. *Write for literature or outline your requirements and let us make recommendations.*

General Alloys

**GENERAL ALLOYS COMPANY**
**390 West First St., Boston 27, Massachusetts**
Offices in Principal Cities
*Specialists in high alloy castings and fabrications for 37 years*

*(Continued from page 14)*

tensite formation is accompanied by a considerable increase in volume. It may happen that the surface bursts as the core expands and hardening cracks arise. Sometimes the object may not crack, but it may distort or warp especially if the shape is not symmetrical.

The object is now completely martensitic and very hard and brittle. Before it is put into use it must be tempered by being heated to a suitable temperature. For plain carbon and low alloy steels, the martensite loses hardness as the tempering temperature increases. For high alloy steels the case is rather different because the hardness remains unaltered or increases in the temperature range 750°-930°F. The usual tempering diagrams give the hardness obtained after tempering at various temperatures.

Figs. 5 and 6 give the tempering charts for SAE O1 and SAE D2. It has been explained that the risk of distortion and cracking in hardening is caused mainly by mechanical stresses set up by the great difference in temperature between the surface and the core after cooling. It should be borne in mind that the cooling causes contraction whereas the formation of martensite causes expansion. If the martensite could be made to transform thoughout the object at the same time, the stresses caused by the transformation would be eliminated. Step-quenching, or martempering, is a move in this direction.

### *Martempering*

Instead of water or oil, the quenching medium is a molten salt or metal bath, the temperature of which is kept at a little over Ms for the particular steel, see Fig. 7. The piece is soaked in the bath until its temperature is the same throughout but not long enough for bainite to form. The piece is then taken out of the bath and allowed to cool in free air or airblast to room temperature.

The martensite formation and the resultant increase in volume now take place during the slow air cooling and is comparatively uniform throughout the entire section because the difference in temperature between the surface and the core is very small. After complete cooling to room temperature, tempering is carried out in the usual way to the hardness desired.

To utilize fully the advantages of step hardening, the quenching in the hot bath must be continued until the whole tool has reached practically the same temperature as the bath. Fig. 8 gives an idea of the times required for this. The time for equalization of the temperature within the limits mentioned is rather independent of the hardening as well as the bath temperatures.

The advantage of step-quenching is the reduced risk of cracks and distortion. The limitations are; first, that the method can be applied only to the oil and air hardening steels; and second, that it requires a suitable hot bath. There is also the matter of carefully avoiding the transformation into soft products during the cooling. Despite these restrictions step-quenching is being more widely used and has proved to be particularly valuable in the treatment of complicated tools and

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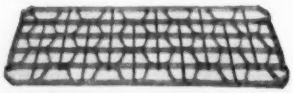
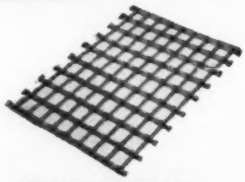

"SERPENTINE"


"PRESSURE WELDED"
Furnished 2-layer or 3-layer

ROLLER HEARTH FURNACE users have found these two basic Rolock Tray designs . . and many possible variations . . . at once efficient and economical.

Not only can Rolock design and construction reduce tray weight (often by 25% to 50%) and thus increase pay-load, but service records frequently show that tray life has doubled or tripled.

These worthwhile savings have resulted from Rolock's engineering approach to tray design, taking into consideration details of the furnace hearth, tray load and weight ratios, method of operation, temperature limits and gradients and many other factors.

"PRESSURE WELDED"
with pusher pads

Complementing correct design, Rolock's unique "Serpentine" and "Pressure-Welded" construction features have proved to be, in many installations, the answer to problems of rapid tray deterioration. That is why Rolock today is a major supplier of furnace trays of these and many special types.

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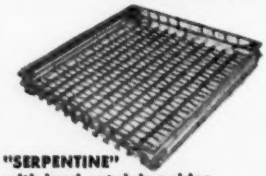
"SERPENTINE"
with load-retaining sides

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST
ROLOCK INC., 1332 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost
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those demanding a high degree of dimensional accuracy.

Table I shows the maximum size of some of the tool steel grades which can be hardened throughout by step-quenching.

### *Bainite Hardening (Austempering)*

This method was developed about 1930. As with step-quenching, cooling takes place in a hot bath, the temperature of which is a little above Ms for the steel. The time in the bath should be arranged to be long enough for the austenite to transform to bainite. Bainite is hard and extremely tough. The hardness with certain steels will be up to 60-61 RC.

For other steels the hardness is, however, considerably lower. Fig. 9 gives the principle of the method.

The hardness of the bainite is influenced by the analysis of the steel and by the temperature of the bath and can therefore to some extent be governed by the temperature. Generally a higher bath temperature gives a lower hardness. The right of the TTT-diagram usually shows the hardness which can be expected after 100 per cent bainite transformation. The method of cooling after the hot bath treatment is not important and no tempering is required.

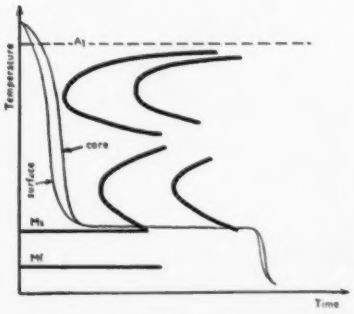


***Fig. 9—Principle of the TTT-diagram showing the conditions on the surface and in the core of a specimen subjected to bainite-hardening (austempering).***

The advantages of this method are as follows:

At a given hardness, toughness is better than with any other method. (An austempered article

*(Continued on page 40)*

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***MARKAL "C-R" COATINGS*** protect against oxidation, corrosion, scaling, gas absorption, carburizing and decarburizing during heat-treating, annealing, normalizing or stress-relieving.

MARKAL "C-R" Coatings protect up to 2100° F. steel, stainless steel, copper, copper bronze, nickel bronze, titanium, zirconium, titanium and molybdenum alloys, inconel and monel metals during heat-treating.

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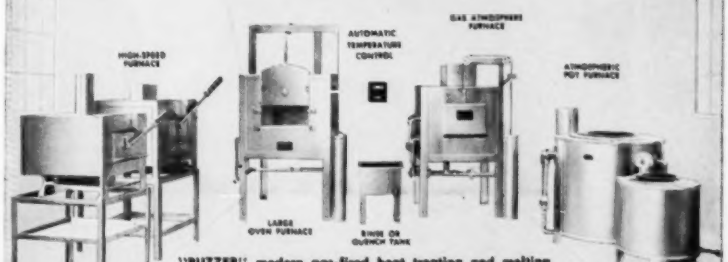


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*(Continued from page 39)*

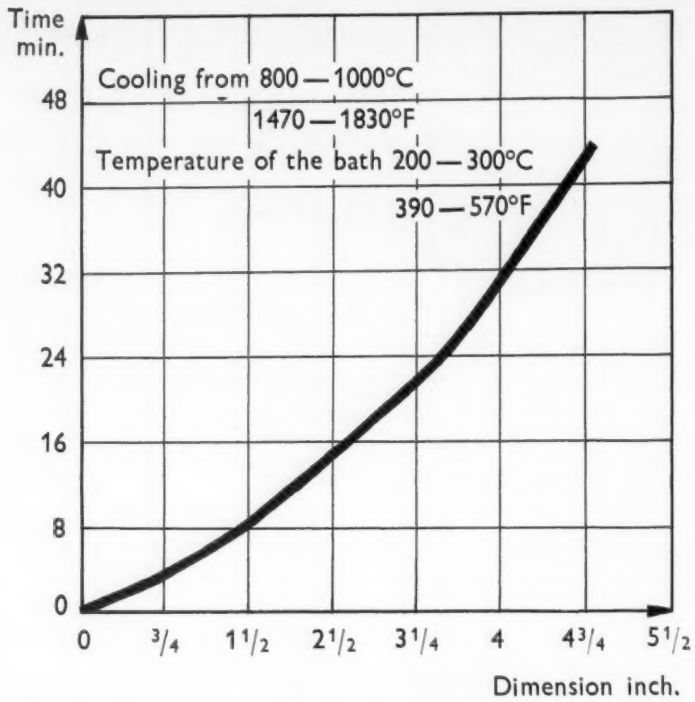


***Fig. 8—Graph showing the shortest time required for the equalization of temperature in cylindrical steel specimens of different diameters. They have been heated to hardening temperature and quenched in a bath of molten salt without circulation of the liquid. The graph is applicable to all steels, whether unalloyed or alloyed.***

**Table I**

| Size inches max. | Austenitizing Temp. °F | Temp. of bath °F | Time in bath minutes | Hardness Rc | | SAE No. |
|---|---|---|---|---|---|---|
| | | | | surface | core | |
| 1¼ | 1510 | 440 | 5 | 63 | 60 | O1 |
| 4 | 1830 | 440 | 30 | 63 | 63 | D2 |

***Maximum size of hardening by step-quenching.***

**Table II**

| Size in inches | Austenitizing Temp. °F | Temperature of bath °F | Time in bath hours | Hardness | |
|---|---|---|---|---|---|
| | | | | surface | center |
| 5/8 | 1490 | 440 | 4 | 60 | 60 |
| 1 1/4 | 1560 | 440 | 6 | 59 | 59 |

***Results of austempering SAE 01.***

is tougher than one that has been hardened and tempered to the same hardness by other methods.)

Accuracy of size is very good and all stresses are relieved.

The method is, however, restricted to small sizes as far as low alloy steels are concerned; with medium alloy steels the range of suitable sizes is wider. With high alloy steels the length of time necesssary for complete transformation becomes too long and uneconomical.

Austempering is applied to small tools requiring exceptional toughness combined with reasonable hardness and for small constructional components in general.

Table II shows results of austempering obtained with SAE O1 tool steel. • • •

## NEWS TO HEAT TREATERS

*(Continued from page 36)*

heat treatment. Specific physicals can be emphasized as desired merely by careful control of heat treatment procedures. Missile castings now being poured by Rolle in this new alloy regularly exceed the physicals specified in MIL-C-21180A.

***For further information circle No. 14***

### TRANSISTORIZED TESTING INSTRUMENT

A new portable eddy current instrument has recently been added to the group of testing systems available from Magnaflux Corporation, Chicago. By accurately measuring electrical conductivity, the battery-powered Magnatest FM-110 Conductivity Meter performs a variety of testing jobs, including the determination of *hardness, alloy, and heat treat condition;* sorting mixed nonmagnetic metals; checking tensile strength of aluminum; investigating fire damage to aircraft; and many others. Readings can be taken on a comparative basis using known samples, or in absolute electrical conductivity units as a percent of the International Annealed Copper Standard.

The FM-110 induces eddy currents within the test piece by means of a ½" diameter hand-held probe. These currents affect the impedance of the probe coil as a function of the conductivity of the material. With the probe on one side of the test piece, the large knob is turned to zero the meter and conductivity is read on the left-hand scale.

***For further information circle No. 15***

# ABSTRACTS

## HEAT TREATING SALES GAIN

If you've been thinking about ordering a heat treating furnace or an induction unit, it might be a good idea to get your inquiry out right now.

For this industry is definitely sharing in metalworking's new buying surge. Some furnace builders are now booked through October. A few months ago these shops were creaking along with skeleton forces and backlogs you could put in your eye. Overtime is up, some find engineers scarce.

Meeting in May at Hot Springs, Virginia, members of the Industrial Heating Equipment Association were more optimistic than they've been in years. So far, the buying wave has not yet hit all builders. Except for steel company orders, there is room for improvement. But April was a whopper.

Furnace orders for the first four months of 1959, at some $25.7 million, are nearly double the $13.2 million figure for the same period of 1958. And inquiries are on the increase. April orders alone topped those booked during the entire first quarter of this year.

Induction heating equipment has posted big gains too. January-April 1959 volume amounted to $4,150,000—against $1,812,000 in the first quarter of last year.

In that field, where steel industry buying is a minor factor, improvement has been fairly general. W. E. Benninghoff, who is Vice President of the Ohio Crankshaft Company, and General Manager of Tocco; and J. A. Logan, head of the newly-merged Ajax-Magnethermic Corporation, are both optimistic about the order outlook. Their backlogs are at least double what they were at the beginning of the year.

H. M. Heyn, President, Surface Combustion Corporation, remarked, "We have budgeted for 25 per cent more business than we had last year. Modernization is paying off for the steel mills. The situation in automotive and farm equipment is a bit different. We're getting some obsolescence business — but their plants are so modern now that we don't look for a big push until they need more volume."

R. A. Schoenfeld, Vice President, Industrial Division, Lindberg Engineering Company, said that business has picked up across the board, particularly in steel, ceramics, and nonferrous. Lindberg now has a six-month backlog.

The chemical industry has a lot of new projects in mind, T. H. Wickwire, President of Trent, Inc., noted. Some are fully engineered and ready to go. When and if they turn these loose, he feels that it will mean quite a boost in many areas.

Still to be heard from in volume is the automobile industry. Some of the heating equipment executives at the meeting report a few orders from that area; others say it's still flat.

Export orders for furnaces continued their climb during 1958 and the first quarter of 1959—a trend which began in 1957.

First quarter '59 exports of furnaces totaled $2,262,000 compared to $1,508,000 in the same 1958 period. And induction equipment exports, at $310,000, were double those in the first quarter of 1958.

*Source: THE IRON AGE*

**You Get Better Results IN HEAT TREATING!**

● Use the NIAGARA AERO HEAT EXCHANGER to control the temperature of your quench bath and you remove the heat *at its rate of input,* always quenching at the exact temperature that will give your product the best physical properties.

The Niagara *Aero* Heat Exchanger transfers the heat to atmospheric air by evaporative cooling. It extends your quenching capacity without using extra water. It pays for itself with water savings.

You can cool and hold accurately the temperature of all fluids, gases, air, water, oils, solutions, chemicals for processes and coolants for mechanical and electrical equipment. You get closed system cooling, free from dirt and scale.

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I have more friends in this country than anybody else, but you'd never know it. I get the feeling America has told me to go fly a kite.

I have built, furnished, heated and paid the taxes on more homes than anybody in history.

I have put shoes on your rambunctious sons and pretty dresses on your smiling daughters.

I am equally at home in a cookie jar, a hip pocket or the First National Bank.

I have built more factories, plowed more fields, fed more hogs, paved more highways than anyone I know.

I paid for your first bottle of milk when you were a baby and I could be your most dependable friend when you get old and retire.

I could, but I'm not indestructible. Inflation could just about ruin me.

I want help. Bankers, financial men and others have tried, but they cannot prevent inflation by themselves.

I want some additional clear-thinking citizens to help keep up my strength.

I want to be healthy so I can live up to my famous slogan, "Sound as a dollar."

*—Newsweek Magazine*

# The Metal Treating Institute

## Annual Achievement Award

***The award is made at the discretion of a Committee appointed to select the Best Article appearing in METAL TREATING magazine or Lecture presented at any meeting of the Institute.***

***The award consists of the presentation of an engraved plaque and $100.00 in cash.***

***This year's award will be presented at the 1959 Annual Meeting of the Institute, and all Articles appearing in any issue of METAL TREATING from September-October 1958 to July-August 1959 or any Lectures presented at the 1958 Annual and 1959 Spring Meetings are eligible for consideration.***

**AWARD COMMITTEE—**

**K. U. Jenks, *President, Metal Treating Institute***
**H. C. Knerr, *Chairman, Publication Committee***
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***Members, Publication Committee***
**C. E. Herington, *Editor, METAL TREATING***

## THE WHY AND HOW OF QUENCHING

*(Continued from page 7)*

products, usually 50 per cent martensite. The calculation of hardenability from the chemical composition of the steel involves the use of an infinite value of H resulting in a $D_I$ value of the steel. This is called the ideal diameter of this heat of steel and is the diameter of a bar of this steel which will produce a structure of 50 per cent martensite at the center of the bar when quenched into a bath where $H = \infty$. $D_C$ is the diameter of a bar of this steel which will harden to 50 per cent martensite at the center when quenched into a bath where H is less than infinity. Therefore it is obvious that a given heat of steel can only have one value of $D_I$, but many values of $D_C$ depending upon the H value of the quenching bath. However, as shown above, the H value of a given quenching bath is a function of the diameter of the bar being quenched.

Many useful correlations have been developed between $D_I$ values, end-quench distance on the Jominy hardenability bar, and depth of hardening below the surface of a given bar diameter. Most of these correlations have been arrived at from the mathematical calculation standpoint assuming the severity of quench, H, and the diffusivity, a, were constant. The severity of quench, H, values suggested for oil and water, for no circulation to violent circulation, are 0.25 to 1.1, and 0.9 to 4 respectively. However, these values are known to be low for small size bars, that is, less than 1" diameter, and high for large size bars.

The intent of this article has not been to discredit hardenability calculations and the useful correlations which have been derived utilizing various assumptions. The intent, on the other hand, has been to review these assumptions and to call attention to the limitations that these assumptions have placed upon hardenability considerations. It must be remembered that the problem of quenching and hardenability has been approached from the heat flow concept utilizing several assumptions, and the only justification for this approach is that actual practice, within reasonable limits, substantiates the heat-flow calculations standpoint. • • •

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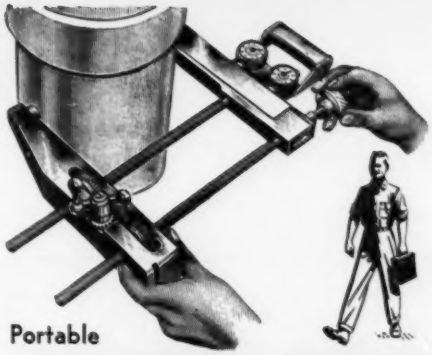

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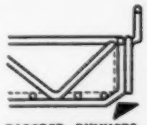

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# MANUFACTURERS' LITERATURE

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### QUALITY CONTROL STANDARDS

Three basic quality control standards newly brought up to date have been approved as American Standards by the American Standards Association. Formerly American War Standards, they are "Guide for Quality Control," Z1.1-1958; "Control Chart Method of Analyzing Data," Z1.2-1958, and "Control Chart Method of Controlling Quality During Production," Z1.3-1958. The new American Standards, sponsored by the American Society for Quality Control, were accepted by 49 national organizations substantially concerned with the scopes and provisions of the standards.

American Standard Z1.1 outlines the basic concepts and philosophy of the Shewhart control chart. Z1.2 provides methods for using the control chart in the analysis of data. Z1.3 provides methods for using the chart in the active control of quality during production.

Step-by-step procedures are given along with examples of application. The standards also provide a definite criterion for judging the character and quantity of information needed to insure that a process is in a state of statistical control. With such control, the quality of the resulting product will have minimum variability and may be predicted with the highest degree of assurance.

These standards also carry the American Society for Quality Control designations ASQC Std B1-1958, ASQC Std B2-1958, and ASQC Std B3-1958. Copies may be obtained from the American Standards Association, Dept PR 72, 70 East 45th Street, New York 17, N. Y. Z1.1-1958 and Z1.2-1958 are combined in one publication and cost $2.25; Z1.3-1958 costs $2.50.

### HIGH TEMPERATURE CARBURIZING

Ipsen Industries, Inc., Rockford, Ill., is offering an 8-page reprint of an article which was published in the January-February 1959 issue of *Metal Treating* entitled "High Temperature Carburizing" by H. N. Ipsen.

***For further information circle No. 16***

### COST ACCOUNTING FOR HEAT TREATING

The Metal Treating Institute, New Rochelle, New York, has published and is offering a 16-page reprint of a series of four papers prepared by the Cost Accounting Committee of the Institute in order to provide a basic cost accounting system for heat treating operations.

The titles of the individual articles bound together in this 16-page booklet are as follows:

"Determination of Expenses"
"Allocation of Expenses"
"Determination of Unit Costs"
"Application of Unit Costs"

***For further information circle No. 17***

### REPRINT AVAILABLE

The American Gas Furnace Co., Elizabeth, N. J., is offering an 8-page reprint of an article which appeared in the January-February 1959 issue of *Metal Treating* entitled "Economic Advantages of Gas-Fired Heat Treating Furnaces" by F. C. Schaefer.

***For further information circle No. 18***

### INDUCTION BRAZING AND SOLDERING

Another issue of *High Frequency Review* is now available. This 12-page illustrated booklet is published by the Lepel High Frequency Laboratories, Inc., and this issue features several articles on the general subject of "High Frequency Induction Brazing and Soldering."

***For further information circle No. 19***

### ELECTRIC PROCESS HEATERS

A new 64-page catalog published by Edwin L. Wiegand Co., Pittsburgh, illustrates the complete line of Chromalox Electric Process Heaters and describes their many uses. This is said to represent the most complete stock of electric process heaters in the world—over 15,000 types of heaters to fit most heating needs.

Also included is a comprehensive application section and a technical section to aid in accurate calculation of heating requirements. Each product is illustrated and described with lists of types, sizes and ratings.

***For further information circle No. 20***

### REFRACTORIES

An 8-page illustrated booklet is available from the Refractories Division of the Carborundum Company entitled *Refractories—Key Components in Equipment.*

***For further information circle No. 21***

### ATOMIC INDUSTRY DIRECTORY

Metals and products and components made of metal figure in 35 out of the 40 major classifications in the 1959 Atomic Industry Directory of Products, Equipment and Services just published by the Atomic Industrial Forum, the association of the nuclear industry. The 132-page book provides data in depth through product and service profiles of more than 200 industrial organizations in the nuclear field.

In addition to its 40 major classifications for products, equipment and services, there are 130 subcategories in the cross-index. The directory which serves as both a buying and marketing guide is available at $2.50 per copy from the Forum at 3 East 54th Street, New York 22, New York—Attention, Department M.

### INFRARED HEAT TREATING

A 48-page technical bulletin, published by The A. F. Holden Co., Detroit metallurgists, describes the firm's new luminous wall combustion system for gas-fired, infrared heat treating furnaces.

Titled "Instantaneous Heat," it sets forth in layman's words the research story behind the luminous wall development, what it is, how it works, its present and future applications, versatility, and a glossary of terms used.

Also included are numerous drawings and prints, for the metallurgist and heat treating engineer, to substantiate the system's unique claim to rapid starting, rapid cooling, and rapid restarting.

***For further information circle No. 22***

### HEAT TREATING BOOKLETS

General Electric Company, Schenectady, has published several illustrated booklets which describe various heat treating processes and equipment.

Please circle the item number for the ones in which you are interested on the Readers' Service Card:

*How to Get the Best Results from Sintering Furnaces*
Circle No. 23

*Protective Atmospheres with Industrial Furnaces*
Circle No. 24

*How to Braze Stainless Steel*
Circle No. 25

### PROS AND CONS OF LEASING

A 20-page booklet has been published by The Foundation for Management Research, Inc., which compiles the results of a study which was made by them for the benefit of smaller manufacturers.

The booklet entitled *The Pros and Cons of Leasing* explains what leasing has to offer smaller business. According to the Foundation, 97 per cent of the manufacturing firms in the United States have fewer than 500 employees, and as for distribution and retailing, most of the companies in those lines are also small and medium-sized enterprises.

***For further information circle No. 26***

### GUIDE FOR COST COMPARISON OF METAL PARTS FINISHING

An informative new cost guide is now available to manufacturers of products fully or partially fabricated from metal. It is known as the Metal Parts Finishing Cost Guide and is especially designed for determining and comparing costs involved in metals finishing procedures: (1) on premises finishing of parts, (2) off premises finishing of parts, and (3) use of pre-finished metals.

Correctly used, the guide can be of invaluable assistance in pinpointing production cost savings. It presents accurate and important cost factors not revealed in "typical studies," surveys, or averages. Comparative figures are confined to the individual operation or sequence of operations for which the guide is used. They take into full account not only raw material prices, but also hidden costs and unrecognized expenses that are frequently overlooked when comparing metal finishing costs.

***For further information circle No. 27***

### PROTECTIVE COATING FOR METALS

A brochure describing the Flame Ceramic Process of protecting metals against temperatures up to 5500°F has been issued by Continental Coatings Corporation, Cleveland.

Continental holds an exclusive license for the Flame Ceramic Process from Armour Research Foundation of Illinois Institute of Technology, Chicago, developer of the process.

It deals also with the current coating of the combustor of the ramjet engine for the supersonic *talos* missile, now in production for the U. S. Navy with Continental's FCA-11 aluminum oxide, and the coating of piston crowns, cylinder-heads and valves for EMD railway diesels of the Chicago & Eastern Illinois Railroad with rare earth oxides.

***For further information circle No. 28***

### HEAT TREATING OVENS

The Turnkey Engineering Company, Inc., South Gate, Calif., is offering a 12-page illustrated booklet which explains its line of heat treating ovens for stress relieving, hydrogen embrittlement applications, and the treatment of steel, aluminum and magnesium parts.

***For further information circle No. 29***

### EQUIPMENT HANDBOOK AVAILABLE

Precision Equipment Co. who regularly publishes a pocket-sized Equipment Manual as a guide to executive planning, is now making to our readers a special introductory offer of a free one-year's subscription to this Manual.

In the Equipment Manual is described and illustrated the newest products and inventions for both plant and office. They include a wide selection of workbenches, the newest developments in adjustable steel shelving, new equipment and material handling inventions.

***For further information circle No. 30***


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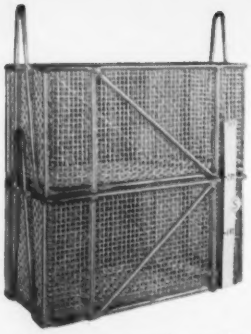

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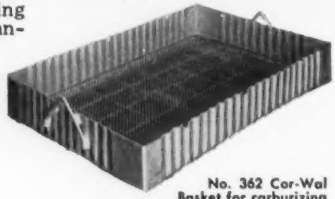

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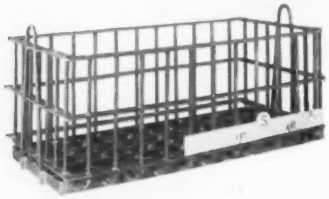

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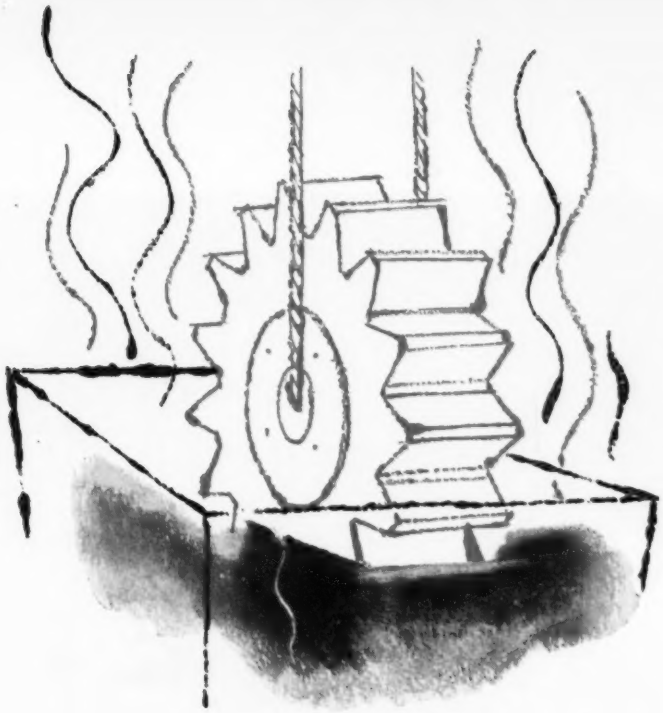

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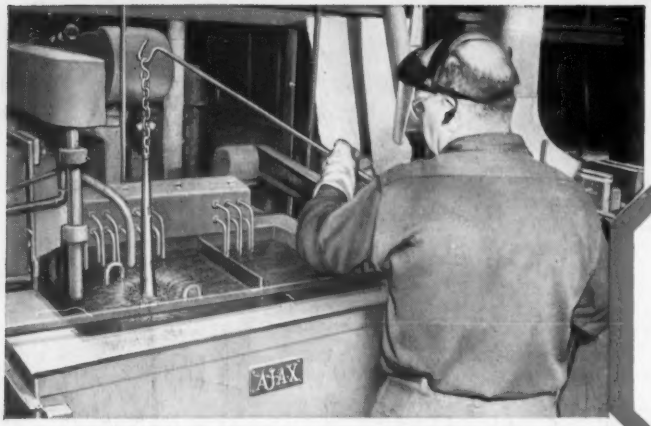

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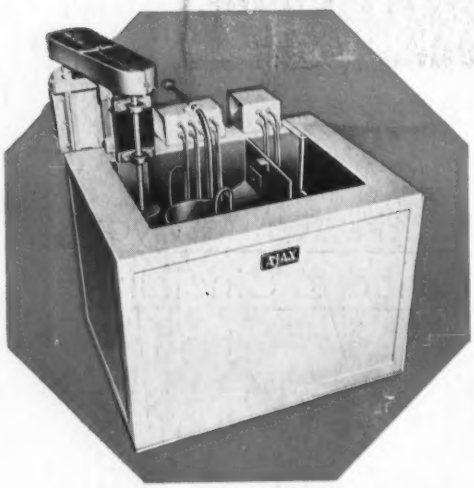

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